STATE BOARD OF TECHNICAL EDUCATION, BIHAR

Scheme of Teaching and Examinations for
Ist Semester
(Effective from Session 2020-21)

THEORY

Sr. No.	SUBJECTS	SUBJECT CODE	TEACHING SCHEME			EXAMINATION – SCHEME							Credits
			Periods per Week			Hours of Exam.	Teacher's Assessment (TA) Marks (A)	Class Test(CT) Marks (B)	End Semester Exam. (ESE) Marks (C)	Total Marks (A+B+C)	Pass Marks ESE	Pass Marks in the Subject	
			L	T	L+T								
1.	Mathematics-I	2001101	02	01	03	03	10	20	70	100	28	40	03
2.	Applied Physics-I	2001102	02	01	03	03	10	20	70	100	28	40	03
3.	Applied Chemistry	2001103	02	01	03	03	10	20	70	100	28	40	03
4.	Communication Skills in English	2001104	02	-	02	03	10	20	70	100	28	40	02
5.	Engg. Graphics	2001105	03		03	03	10	20	70	100	28	40	02
	Total:-		**11**	**03**	**14**				**350**	**500**			**13**

PRACTICAL

Sr. No.	SUBJECTS	SUBJECT CODE	TEACHING SCHEME	EXAMINATION – SCHEME					Credits
			Periods per Week	Hours of Exam.	Practical		Total Marks	Pass Marks in the Subject	
					Internal(PA)	External(ESE)			
6.	Applied Physics Lab-I	2001106	03	03	15	35	50	20	02
7.	Applied Chemistry Lab	2001107	03	03	15	35	50	20	02
8.	Communication Skills in English Lab	2001108	03	03	15	35	50	20	02
	Total:-		**09**				**150**		**06**

TERM WORK

Sr. No.	SUBJECTS	SUBJECT CODE	TEACHING SCHEME	EXAMINATION – SCHEME				Credits
			Periods per week	Marks of Internal (PA)	Marks of External (ESE)	Total Marks	Pass Marks in the Subject	
9.	Engg. Workshop Practice	2001109	06	07	18	25	10	02
10.	Sports and Yoga	2001110	02	07	18	25	10	02
11.	C/KYP/IT Essential / Python/ Others	2001111	-	15	35	50	20	01
	Total:-		**08**			**100**		**05**
Total Periods per week Each of duration One Hour **31**				**Total Marks = 750**				**24**

MATHEMATICS-I

Subject Code 2001101	Theory			No of Periods in One Session : 45			Credits
	No. of Periods Per Week			Full Marks	:	100	03
	L	T	P/S	ESE	:	70	
	02	01	-	TA	:	10	
	-	-	-	CT	:	20	

Course Objectives:

This course is designed to give a comprehensive coverage at an introductory level to the subject of Trigonometry, Co-ordinate Geometry, Basic elements of algebra and Matrices.

Course Content:

UNIT - I: Trigonometry [09]

Concept of angles, measurement of angles in degrees, grades and radians and their conversions, T-Ratios of Allied angles (without proof), Sum, difference formulae and their applications (without proof). Product formulae (Transformation of product to sum, difference and vice versa).T- Ratios of multiple angles, sub-multiple angles (2A, 3A, A/2). Graphs of sin x, cos x, tan x and e^x **.**Concept of inverse circular function.

UNIT - II: Co-Ordinate Geometry [17]

Equation of straight line in various standard forms (without proof), intersection of two straight lines,

Angle between two lines. Parallel and perpendicular lines, perpendicular distance formula.

General equation of a circle and its characteristics. To find the equation of a circle, given:

i. Centre andradius,

ii. Three points lying on itand

iii. Coordinates of end points of adiameter;

Definition of conics (Parabola, Ellipse, Hyperbola) their standard equations (without proof). Problems on conics when their foci, directories or vertices are given.

UNIT - III: Algebra

ComplexNumbers: Definition,realandimaginarypartsofaComplexnumber,polarandcartesian **[04]** representation of a complex number and its conversion from one form to other, conjugate of a complexnumber,modulusandamplitudeofacomplexnumber.Addition,Subtraction,Multiplicationand Division of complex numbers,De-moivre’s theorem (without proof)and itsapplication.

Partial fractions: Definition of polynomial fraction, proper & improper fractions and definition **[03]** of partial fractions. To resolve proper fraction into partial fraction with denominator containing non-repeated linear factors, repeated linear factors and irreducible non-repeated quadratic factors. To resolve improper fraction into partialfraction.

Permutations and Combinations: Definition of Factorial Notation, Introduction of **[02]**

Permutation & Combination,Value of ${}^nP_r$ and ${}^nC_r$.

Binomial Theorem: Binomial theorem (without proof) for positive integral index (expansion **[04]** and general form); binomial theorem for any index (expansion without proof) first and second binomial approximation with applications to engineering problems

Determinants and Matrices **[06]**

Elementary properties of determinants up to 3rd order, consistency of equations, Crammer's rule.Algebraofmatrices, Transpose of a matrix, Adjoint of a matrix, Inverseofamatrix, (by adjoint method), matrixinversemethodtosolveasystemoflinearequations in2 or 3variables.

References:

1. B.S.Grewal,HigherEngineeringMathematics,KhannaPublishers,NewDelhi,40th Edition,2007.
2. ReenaGarg,EngineeringMathematics,KhannaPublishingHouse,NewDelhi(RevisedEd.2018)
3. Mathematics Today - XI & XII (Part I) byLalji Prasad (Paramount Publication, GovindMitra Road).
4. A Text Book of Mathematics-XI & XII (Vol-1) by K.C. Sinha-Rastogi Publication, Meerut
5 ReenaGarg&ChandrikaPrasad,AdvancedEngineeringMathematics,Khanna PublishingHouse, New Delhi

Course Outcomes:

By the end of the course, the students are expected to learn

(i) The students are expected to acquire necessary background in Trigonometry to appreciatethe importance of the geometric study as well as for the calculation and the mathematical analysis.

(ii) The ability to find the effects of changing conditions on asystem.

(iii) thecoordinategeometryprovidesaconnectionbetweenalgebraandgeometrythrough graphs of lines andcurves.

(iv) Complexnumbersenterintostudiesofphysicalphenomenainwaysthatmostpeoplecannot imagine.

(v) The students are expected to acquire necessary background in Determinants and Matrices so as to appreciate the importance of the Determinants are the factors that scale different parameterizations so that they all produce same overall integrals, i.e. they are capable of encoding the inherent geometry of the originalshape.

APPLIED PHYSICS-I

<table>
<tr><td rowspan="5">Subject Code
2001102</td><td colspan="3">Theory</td><td colspan="3">No of Periods in One Session : 45</td><td>Credits</td></tr>
<tr><td colspan="3">No. of Periods Per Week</td><td>Full Marks</td><td>:</td><td>100</td><td rowspan="4">03</td></tr>
<tr><td>L</td><td>T</td><td>P/S</td><td>ESE</td><td>:</td><td>70</td></tr>
<tr><td>02</td><td>01</td><td>-</td><td>TA</td><td>:</td><td>10</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>CT</td><td>:</td><td>20</td></tr>
</table>

Course Objectives:

Applied Physics includes the study of a large number of diverse topics all related to materials/things that exist in the world around us. It aims to give an understanding of this world both by observation and by prediction of the way in which such objects behave. Concrete use of physical principles and analysis in various fields of engineering and technology are given prominence in the course content. The course will help the diploma engineers to apply the basic concepts and principles to solve broad- based engineering problems and to understand different technology based applications.

Teaching Approach:

- Teachers should give examples from daily routine as well as, engineering/technology applications on various concepts and principles in each topic so that students are able to understand and grasp these concepts and principles. In all contents, SI units should be followed.
- Use of demonstration can make the subject interesting and develop scientific temper in the students. Student activities should be planned on all the topics.
- Activity- Theory - Demonstrate/practice approach may be followed throughout the course so that learning may be outcome and employability based.

Course Content:

Unit 1: Physical world, Units and Measurements [05]

Physical quantities; fundamental and derived, Units and systems of units (FPS, CGS and SI units), Dimensions and dimensional formulae of physical quantities, Principle of homogeneity of dimensions, Dimensional equations and their applications (conversion from one system of units to other, checking of dimensional equations and derivation of simple equations), Limitations of dimensional analysis.

Measurements: Need, measuring instruments, least count, types of measurement (direct, indirect), Errors in measurements (systematic and random), absolute error, relative error, error propagation, error estimation and significant figures.

Unit 2: Force and Motion [09]

Scalar and Vector quantities – examples, representation of vector, types of vectors. Addition and Subtraction of Vectors, Triangle and Parallelogram law (Statement only), Scalar and Vector Product, Resolution of a Vector and its application to inclined plane and lawn roller.

Force, Momentum, Statement and derivation of conservation of linear momentum, its applications such as recoil of gun, rockets, Impulse and its applications.

Circular motion, definition of angular displacement, angular velocity, angular acceleration, frequency, time period, Relation between linear and angular velocity, linear acceleration and angular acceleration (related numerical), Centripetal and Centrifugal forces with live examples, Expression and applications such as banking of roads and bending of cyclist.

Unit 3: Work, Power and Energy **[09]**

Work: Concept and units, examples of zero work, positive work and negative work Friction: concept, types, laws of limiting friction, coefficient of friction, reducing friction and its engineering applications, Work done in moving an object on horizontal and inclined plane for rough and plane surfaces and related applications.

Energy and its units, kinetic energy, gravitational potential energy with examples and derivations, mechanical energy, conservation of mechanical energy for freely falling bodies, transformation of energy (examples).

Power and its units, power and work relationship, calculation of power (numerical problems).

Unit 4: Rotational Motion **[08]**

Translational and rotational motions with examples, Definition of torque and angular momentum and their examples, Conservation of angular momentum (quantitative) and its applications.

Moment of inertia and its physical significance, radius of gyration for rigid body, Theorems of parallel and perpendicular axes (statements only), Moment of inertia of rod, disc, ring and sphere (hollow and solid); (Formulae only).

Unit 5: Properties of Matter **[08]**

Elasticity: definition of stress and strain, modulus of elasticity, Hooke's law, significance of stress-strain curve.

Pressure: definition, units, atmospheric pressure, gauge pressure, absolute pressure, Fortin's Barometer and its applications.

Surface tension: concept, units, cohesive and adhesive forces, angle of contact, Ascent Formula (No derivation), applications of surface tension, effect of temperature and impurity on surface tension.

Viscosity and coefficient of viscosity: Terminal velocity, Stokes law and effect of temperature on viscosity, application in hydraulic systems.

Hydrodynamics: Fluid motion, stream line and turbulent flow, Reynolds number Equation of continuity, Bernoulli's Theorem (only formula and numerical) and its applications.

Unit 6: Heat and Thermometry **[06]**

Concept of heat and temperature, modes of heat transfer (conduction, convection and radiation with examples), specific heats, scales of temperature and their relationship, Types of Thermometer (Mercury thermometer, Bimetallic thermometer, Platinum resistance thermometer, Pyrometer) and their uses.

Expansion of solids, liquids and gases, coefficient of linear, surface and cubical expansions and relation amongst them, Co-efficient of thermal conductivity, engineering applications.

Learning Outcome:

After undergoing this subject, the student will be able to:

- Identify physical quantities, select their units for use in engineering solutions, and make measurements with accuracy by minimizing different types of errors.
- Represent physical quantities as scalar and vectors and solve real life relevant problems.
- Analyse type of motions and apply the formulation to understand banking of roads/railway tracks and conservation of momentum principle to describe rocket propulsion, recoil of gun etc.
- Define scientific work, energy and power and their units. Derive relationships for work, energy and

power and solve related problems.

- Describe forms of friction and methods to minimize friction between different surfaces.
- State the principle of conservation of energy. Identify various forms of energy, and energy transformations.
- Compare and relate physical properties associated with linear motion and rotational motion and apply conservation of angular momentum principle to known problems.
- Describe the phenomenon of surface tension, effects of temperature on surface tension and solve statics problems that involve surface tension related forces.
- Describe the viscosity of liquids, coefficient of viscosity and the various factors affecting its value. Determine viscosity of an unknown fluid using Stokes' Law and the terminal velocity.
- Define stress and strain. State Hooke's law and elastic limits, stress–strain diagram, determine; (a) the modulus of elasticity, (b) the yield strength (c) the tensile strength, and (d) estimate the percent elongation.
- Illustrate the terms; heat and temperature, measure temperature in various processes on different scales (Celsius, Fahrenheit, and Kelvin etc.)
- Distinguish between conduction, convection and radiation; identify different methods for reducing heat losses and mode of heat transfer between bodies at different temperatures.
- State specific heats and measure the specific heat capacity of solids and liquids.

References:

1. Text Book of Physics for Class XI& XII (Part-I, Part-II); N.C.E.R.T., Delhi
2. Applied Physics, Vol. I and Vol. II, TTTI Publications, Tata McGraw Hill, Delhi.
3. Concepts in Physics by HC Verma, Vol. I & II, Bharti Bhawan Ltd. New Delhi
4. Engineering Physics by PV Naik, Pearson Education Pvt. Ltd, New Delhi
5. Engineering Physics by DK Bhhatacharya & PoonamTandan; Oxford University Press, New Delhi.
6. Comprehensive Practical Physics, Vol, I & II, JN Jaiswal, Laxmi Publications (P) Ltd., New Delhi
7. Practical Physics by C. L. Arora, S. Chand Publication.
8. e-books/e-tools/ learning physics software/websites etc.

APPLIED CHEMISTRY

Subject Code	Theory			No of Periods in One Session : 45			Credits
Subject Code 2001103	No. of Periods Per Week			Full Marks	:	100	03
	L	T	P/S	ESE	:	70	
	02	01	-	TA	:	10	
	-	-	-	CT	:	20	

Course Objectives:

There are numerous number materials used in fabricating and manufacturing devices for the comfort of life. The selection, characterization and suitability assessment of natural raw materials essentially requires principles and concepts of Applied Chemistry for students. On successful completion of this course :-

- The students will be able to understand, ascertain and analyse the properties of natural raw materials required for producing economical and eco-friendly finished products.
- Solve various engineering problems applying the basic knowledge of atomic structure and chemical bonding.
- Use relevant water treatment method to solve domestic and industrial problems.
- Solve the engineering problems using knowledge of engineering materials and properties.
- Use relevant fuel and lubricants for domestic and Industrial applications
- Solve the engineering problems using concept of Electrochemistry and Corrosion.

Course Content :

UNIT-I Atomic Structure and Chemical Bonding. [10]

Rutherford Model of Atom, Photoelectric Effect, Bohr's Theory (Expression of Energy and Radius to be omitted) and hydrogen spectrum explanation based on Bohr's Model of Atom, Wave Mechanical model of atom, de Broglie relationship, Heisenberg Uncertainty Principle, Quantum Number, Shapes of Atomic Orbitals, Pauli's Exclusion Principle, Hund's Rule of Maximum Multiplicity, Aufbau Principle, Electronic Configuration (till atomic number 30).

Concept of Chemical bonding – Cause of chemical bonding, Types of Bonds : Ionic Bond (NaCl, $CaCl_2$, MgO), Covalent Bond, Polar and Non polar Covalent Bonds (H_2, F_2, HF, HCl) & Co-ordinate Bond (CO, NH_4+, O_3, H_2SO_4), Dipole Moment (NH_3, NF_3), Hydrogen bonding, Anamalous properties of NH_3,H_2O due to Hydrogen Bonding .

Concept of Hybridisation, Structure and Shape of Simple Inorganic Molecule e.g. $BeCl_2$, BF_3, CH_4, NH_3, H_2O on the basis of hybridisation.

UNIT-II Water [08]

Introduction, Sources of Water, Hardness of Water, Degree of Hardness (In terms of $CaCO_3$ equivalent), Unit of Hardness, Quantitative Measurement of Water Hardness by EDTA method. Municipal supply of Water, Disinfection of Water.

Water Softening Technique-Soda Lime Process, Determination of Dissolved Oxygen, Water Quality Index – Biological Oxygen Demand, Chemical Oxygen Demand, Simple Numerical Problems.

UNIT-III Engineering Materials. [08]

Natural Occurrence of Metals, Metallurgy – brief account of general principles of Metallurgy, Gangue, Flux and Slag, Extraction of Aluminum, Iron and Copper from their important ores along with reactions.

Alloys – Definition, Purpose of Alloying, Ferrous and Non Ferrous Alloy with suitable examples, Composition, Properties and Applications.

Polymers–Homopolymers and Copolymers, Addition and Condensation Polymerization e.g. Polythene, Orlon, Terylene, Nylon 66, Nylon 6, Bakelite, Thermoplastic and Thermosetting plastic, Rubber and Vulcanization of Rubber with Chemical Reaction.

UNIT-IV **Chemistry of Fuel and Lubricants.** **[09]**

Definition of Fuel, Characteristics of an Ideal Fuel, Classification of Fuel, Calorific Values (HCV and LCV), Determination of Calorific Value by using Bomb Calorimeter, Calculation of HCV and LCV using Dulong's formula.

Petrol and Diesel-Fuel Rating (Octane and Cetane Number), Chemical Composition, Calorific Values and Application of LPG, CNG and Biogas.

Lubricants-Functions and Properties of Good Lubricant, Viscosity & Viscosity Index, Flash point, Fire point, Cloud & Pour point, Classification of Lubricants with examples.

UNIT-V **Electrochemistry.** **[10]**

Introduction, Electrolyte and Non electrolyte, Arrhenius Theory of Ionization, Electrolytic and Metallic Conduction, Factors affecting Electrolytic Conductance, Ohm's law, Molar Conductivity and Equivalent Conductivity, Variation of Molar Conductivity, Kohlrausch's law, Electrolysis, Faraday's Laws of Electrolysis and simple numerical problems.

Galvanic Cell, Electrode Potential, Measurement of Electrode Potential NHE (Normal Hydrogen electrode) EMF, Electrochemical Series, Nernst Equation for Electrode Potential.

Batteries, (Commercial Cells) - Primary cells-Dry cell, Secondary cell -Lead storage battery, Fuel cells.

Corrosion as an Electrochemical Process.

Learning Outcomes

At the end of the course student will be able to

1. Understand the classification and general properties of engineering materials such as metal, alloys, and composite materials using knowledge of chemical bonding.
2. Understand and assess the suitability of water source for domestic and industrial application, effluents and minimize water pollution.
3. Qualitatively analyze the engineering materials and understand their properties and applications.
4. Choose fuel and lubricants suitable for economical industrial processing to obtain eco-friendly finished products.
5. a) Ascertain construction, mechanism efficiency of electrochemical cells, solar cell fuel cells

   b) Understand corrosion and develop economical prevention techniques.

References/Suggested Learning Resources:

(a) Books :

1) Text Book of Chemistry for Class XI& XII (Part-I, Part-II); N.C.E.R.T., Delhi, 2017-18.
2) Agrawal, & Shikha, Engineering Chemistry, Cambridge University Press; New Delhi, 2015.
3) C.N. R. Rao, Understanding Chemistry, Universities Press (India) Pvt. Ltd., 2011.
4) Dara, S. S. & Dr.S.S.Umare, Engineering Chemistry, S.Chand. Publication, New Delhi, 2015.
5) Jain & Jain, Engineering Chemistry, Dhanpat Rai and Sons; New Delhi, 2015.
6) Dr. Vairam, S., Engineering Chemistry, Wiley India Pvt.Ltd., New Delhi, 2013.
7) Dr. G. H. Hugar & Prof A. N. Pathak, Applied Chemistry Laboratory Practices, Vol. I and Vol. II, NITTTR, Chandigarh, Publications, 2013-14.
8) Agnihotri, Rajesh, Chemistry for Engineers, Wiley India Pvt.Ltd., 2014.

(b) Open source software and website address:

1 www.chemguide.co.uk/atommenu.html (Atomic structure and chemical bonding)
2 www.visionlearning.com (Atomic structure and chemical bonding)
3 www.chem1.com (Atomic structure and chemical bonding)
4 https://www.wastewaterelearning.com/elearning/ (Water Treatment)
5 www.capital-refractories.com (Metals, Alloys, Cement, and Refractory Materials)
6 www.em-ea.org/guide%20books/book-2/2.1%20fuels%20and%20combustion.pdf (Fuel and Combustion)
7 www.chemcollective.org (Metals, Alloys)
8 www.wqa.org(Water Treatment)

COMMUNICATION SKILLS IN ENGLISH

	Theory			No of Periods in One Session : 30			Credits
Subject Code 2001104	No. of Periods Per Week			Full Marks	:	100	02
	L	T	P/S	ESE	:	70 (50Eng.+20 Hindi)	
	02	-	-	TA	:	10	
	-	-	-	CT	:	20	

Course Objectives:

Communication skills play an important role in career development. This course aims at introducing basic concepts of communication skills with an emphasis on developing personality of the students. Thus, the main objectives of this course are:

To develop confidence in speaking English with correct pronunciation;

To develop communication skills of the students i.e. listening, speaking, reading and writing skills; and

To introduce the need for personality development.

Focus will be on developing certain qualities which will aid students in handling personal and career challenges, leadership skills etc.

Course Content :

Part - A (English) **F.M. - 50(English)**

UNIT - 1 **COMMUNICATION: THEORY AND PRACTICE** **[04]**

- **Basics of Communication:** Introduction, Meaning and Definition, Process of Communication, Elements of Communication: Sender-Message-Channel-Receiver-Feedback & Context, Feedback: Definition & Importance.
- **Types of Communication:** Formal and Informal, Verbal-Non-verbal, Types of Verbal Communication: Oral and Written, Non-Verbal Codes such as Kinesics, Proxemics, Haptics, Vocalics, Chronemics, Physical Appearance; Tables, Charts and Graphs in Graphic Communication Oral and Written.

UNIT - 2 **EFFECTIVE COMMUNICATION AND COMMUNICATION BARRIERS** **[04]**

- **Concept, 7 Cs for Effective Communication (Considerate, Concrete, Concise, Clear, Complete, Correct, Courteous);**
- **Art of Effective Communication: Choosing Words, Voice, Modulation, Clarity, Time, Simplification of Words.**
- **Different Barriers to Communication, Ways to Remove/Minimize.**

UNIT - 3 **READING COMPREHENSION** **[03]**

- **Comprehension and Vocabulary enhancement based on reading of the following texts:**

SECTION-1

Malgudi Days:	**R.K. Narayan**
What Students Can Do:	**Mohandas Karamchand Gandhi**
The Secret of Work :	**Swami Vivekanand**

SECTION-2

Stopping by Woods on a Snowy Evening:	**Robert Frost**
Where the Mind Is without Fear:	**Rabindranath Tagore**
Ode on Solitude:	**Alexander Pope**
A Psalm of Life:	**H.W. Longfellow**

UNIT - 4 FORMAL WRITTEN SKILLS/PROFESSIONAL WRITING [04]

- **Application to Principal/Librarian.**
- **Drafting E-mails, Messages and Notices.**
- **Business Letters: Enquiry Letter, Order Letter, Complaint Letter, Adjustment Letter.**
- **Application / Official Letter Writing.**
- **Report Writing.**

UNIT - 5 VOCABULARY AND GRAMMAR [05]

- **Vocabulary of Common Words.**
- **One Word Substitution, Common Idioms and Phrases.**
- **Use of Synonyms & Antonyms.**
- **Parts of Speech, Simple Sentence and Question, Adding Question-Tags, Removal of 'Too', Active Voice into Passive Voice, Direct Speech into Indirect Speech (in cases of Simple Sentence and Question), Punctuation.**

Part-B (Hindi) कुल–20 अंक (हिन्दी)

UNIT - 1. सम्प्रेषण - सिद्धांत एवं व्यवहार **[02]**

सम्प्रेषण - परिचय, अर्थ एवं परिभाषा, सम्प्रेषण की प्रक्रिया

1. सम्प्रेषण के प्रकार - औपचारिक एवं अनौपचारिक, शाब्दिक एवं अशाब्दिक
2. प्रभावशाली सम्प्रेषण के सिद्धांत एवं व्यवधान
3. प्रभावशाली सम्प्रेषण कौशल - शब्द चयन, आवाज़, स्वर परिवर्तन, स्वर सामंजस्य, स्पष्टता, शब्दों की सरलता
4. तकनीकी सम्प्रेषण

UNIT - 2. . व्यावसायिक उत्कृष्टता हेतु व्यवहार कौशल **[02]**

1. परिचय - तकनीकी कौशल एवं व्यवहार कौशल
2. व्यवहार कौशल का महत्व
3. जीवन कौशल - आत्म जागरूकता एवं आत्म विश्लेषण
4. भावनात्मक बुद्धिमता एवं करुणा, अनुकूलनशीलता एवं लचीलापन
5. व्यवहार कौशल का उपयोग - वृत्त अध्ययन

UNIT - 3. **पाठ बोध** शब्दावली परिवर्द्धन एवं व्याकरण अभ्यास **[02]**

निर्धारित पाठय सामग्री -

(क) प्रेमचंद की कहानियाँ - शतरंज के खिलाड़ी, नमक का दारोगा, ईदगाह, पूस की रात

(ख) रविन्द्रनाथ टैगोर की रचना-मन जहां भय से मुक्त हो

(ग) कबीर के पद एवं दोहे

UNIT - 4. लेखन कौशल **[02]**

1. सार लेखन
2. औपचारिक पत्र लेखन - कार्मिक एवं व्यावसायिक पत्र , सरकारी पत्र, अर्द्धसरकारी पत्र–लेखन
3. प्रारूप लेखन - सूचना, बायोडाटा, निविदा लेखन, प्रतिवेदन–लेखन

UNIT - 5. शब्दावली एवं व्याकरण **[02]**

1. सामान्य शब्दावली
2. प्रशासनिक शब्दावली
3. शब्द भेद, अनेक शब्दों के लिए एक शब्द
4. विराम चिन्ह
5. मुहावरें एवं कहावतें

References:

1. J.D.O'Connor. *Better English Pronunciation.* Cambridge: Cambridge University Press, 1980.
2. Lindley Murray. *An English Grammar: Comprehending Principles and Rules.* London: Wilson and Sons, 1908.
3. Kulbhushan Kumar, Effective Communication Skills, Khanna Publishing House, New Delhi (Re- vised Edition 2018)
4. Margaret M. Maison. *Examine your English.* Orient Longman: New Delhi, 1964.
5. M. Ashraf Rizvi. *Effective Technical Communication*. Mc-Graw Hill: Delhi, 2002.
6. John Nielson. *Effective Communication Skills.* Xlibris, 2008.
7. *Oxford Dictionary*
8. *Roget's Thesaurus of English Words and Phrases*
9. *Collin's English Dictionary*

Course outcomes:

At the end of this course, the participants will:

- Develop basic speaking and writing skills including proper usage of language and vocabulary so that they can become highly confident and skilled speakers and writers.
- Be informed of the latest trends in basic verbal activities such as presentations, facing interviews and other forms of oral communication.
- Also develop skills of group presentation and communication in team.
- Develop non-verbal communication such as proper use of body language and gestures.

ENGG. GRAPHICS

Subject Code 2001105	Theory			No of Periods in One Session : 45			Credits
	No. of Periods Per Week			Full Marks	:	100	02
	L	T	P/S	ESE	:	70	
	03	-	-	TA	:	10	
	-	-	-	CT	:	20	

Course Objectives:

- To understand the language of graphics which is used to express ideas, convey instructions while carrying out engineering jobs.
- To develop drafting and sketching skills, to know the applications of drawing equipments, and get familiarize with Indian Standards related to engineering drawings.
- To develop skills to visualize actual object or a part of it, on the basis of drawings.
- To develop skills to translate ideas into sketches and to draw and read various engineering curves, projections and dimensioning styles.
- To understand the basic commands and develop basic skills related to computer aided drafting, of how to draw, modify, and edit basic shapes (2D), using AUTOCAD.

Course Content

UNIT – I Basic elements of Drawing [06]

Drawing Instruments and supporting materials: method to use them with applications. Convention of lines and their applications.

Representative Fractions – reduced, enlarged and full size scales; Engineering Scales such as plain and diagonal scale.

Dimensioning techniques as per SP-46:2003 – types and applications of chain, parallel and coordinate dimensioning.

Geometrical and Tangency constructions. (Redraw the figure)

UNIT – II Orthographic projections [08]

Introduction of projections-orthographic, perspective, isometric and oblique: concept and applications.

Introduction to orthographic projection, First angle and Third angle method, their symbols.

Conversion of pictorial view into Orthographic Views – object containing plain surfaces, slanting surfaces, slots, ribs, cylindrical surfaces. (use First Angle Projection method only)

UNIT – III Isometric Projections [08]

Introduction to isometric projections.

Isometric scale and Natural scale.

Isometric view and isometric projection.

Illustrative problems related to objects containing lines, circles and arcs shape only. Conversion of orthographic views into isometric view/projection.

UNIT – IV Free Hand Sketches of engineering elements [07]

Free hand sketches of machine elements: Thread profiles, nuts, bolts, studs, set screws, washer, Locking arrangements. (For branches other than mechanical Engineering, the teacher should select branch specific elements for free hand sketching) Free hand sketches of orthographic view (on squared graph paper) and isometric view (on isometric grid paper)

UNIT – V Computer aided drafting interface [08]

Computer Aided Drafting: concept. Hardware and various CAD software available.

System requirements and Understanding the interface.

Components of AutoCAD software window: Title bar, standard tool bar, menu bar, object properties tool bar, draw tool bar, modify tool bar, cursor cross hair. Command window, sta- tus bar, drawing area, UCS icon.

File features: New file, Saving the file, Opening an existing drawing file, Creating templates, Quit.

Setting up new drawing: Units, Limits, Grid, Snap.

Undoing and redoing action.

UNIT – VI Computer aided drafting [08]

Draw basic entities like Line, Circle, Arc, Polygon, Ellipse, Rectangle, Multiline, PolyLine.

Method of Specifying points: Absolute coordinates, Relative Cartesian and Polar coordinates.

Modify and edit commands like trim, extend, delete, copy, offset, array, block, layers.

Dimensioning: Linear, Horizontal Vertical, Aligned, Rotated, Baseline, Continuous, Diameter, Radius, Angular Dimensions.

Dim scale variable.

Editing dimensions.

Text: Single line Text, Multiline text.

Standard sizes of sheet. Selecting Various plotting parameters such as Paper size, paper units, Drawing orientation, plot scale, plot offset, plot area, print preview.

S. No.	Exercises	Unit No.
1	Draw horizontal, Vertical, 30 degree, 45 degree, 60 and 75 degrees lines, different types of lines, dimensioning styles using Tee and Set squares/ drafter. (do this exercise in sketch book)	I
2	Write alphabets and numerical (Vertical only) (do this exercise in sketch book)	I
3	Draw regular geometric constructions and redraw the given figure (do this exercise in sketch book) Part I	II
4	Draw regular geometric construction and redraw the given figure (do this exercise in sketch book) Part II	II
5	Draw a problem on orthographic projections using first angle method of projection having plain surfaces and slanting. Part I	III
6	Draw another problem on orthographic projections using first angle method of projection having slanting surfaces with slots. Part II	III
7	Draw two problems on orthographic projections using first angle method of projection having cylindrical surfaces, ribs. Part I	III
8	Draw two problems on Isometric view of simple objects having plain and slanting surface by using natural scale. Part I	IV
9	Draw some problems on Isometric projection of simple objects having cylindrical surface by using isometric scale. Part I	IV

10	Draw free hand sketches/ conventional representation of machine elements `in sketch book such as thread profiles, nuts, bolts, studs, set screws, washers, Locking arrangements. Part I	V
11	Problem based Learning: Given the orthographic views of at least three objects with few missing lines, the student will try to imagine the corresponding objects, complete the views and draw these views in sketch book. Part I	III, II, V
12	Draw basic 2D entities like: Rectangle, Rhombus, Polygon using AutoCAD (Print out should be a part of progressive assessment). Part I	V
13	Draw basic 2D entities like: Circles, Arcs, circular using AutoCAD (Printout should be a part of progressive assessment). Part II	V
14	Draw basic 2D entities like: Circular and rectangular array using AutoCAD (Printout should be a part of progressive assessment). Part III	V
15	Draw blocks of 2D entities comprises of Rectangle, Rhombus, Polygon, Circles, Arcs, circular and rectangular array, blocks using AutoCAD (Print out should be a part of progressive assessment). Part IV	V
16	Draw basic branch specific components in 2D using AutoCAD (Print out should be a part of term work). Part I	VI
17	Draw complex branch specific components in 2D using AutoCAD (Print should be a part of progressive assessment). Part I	VI
	Total	

SUGGESTED LEARNING RESOURCES

1. Bureau of Indian Standards. *Engineering Drawing Practice for Schools and Colleges IS: Sp-46*. BIS. Government of India, Third Reprint, October 1998; ISBN: 81-7061-091-2.
2. Bhatt, N. D. *Engineering Drawing*. Charotar Publishing House, Anand, Gujrat 2010; ISBN: 978-93- 80358-17-8.
3. Jain & Gautam, Engineering Graphics & Design, Khanna Publishing House, New Delhi (ISBN: 978- 93-86173-478)
4. Jolhe, D. A. *Engineering Drawing*. Tata McGraw Hill Edu. New Delhi, 2010; ISBN: 978-0-07- 064837-1
5. Dhawan, R. K. *Engineering Drawing*. S. Chand and Company, New Delhi; ISBN: 81-219-1431-0.
6. Shah, P. J. *Engineering Drawing*. S. Chand and Company, New Delhi, 2008, ISBN:81-219-2964-4.
7. Kulkarni, D. M.; Rastogi, A. P.; Sarkar, A. K. *Engineering Graphics with AutoCAD*. PHI Learning Pri- vate Limited-New Delhi (2010); ISBN: 978-8120337831.
8. Jeyapoovan, T. *Essentials of Engineering Drawing and Graphics using AutoCAD*. Vikas Publishing HousePvt. Ltd, Noida, 2011; ISBN: 978-8125953005.
9. Autodesk. *AutoCAD User Guide*. Autodesk Press, USA, 2015.

10. Sham, Tickoo. *AutoCAD 2016 for Engineers and Designers*. Dreamtech Press; Galgotia Publication, New Delhi, 2015; ISBN 978-9351199113.

Software/Learning Websites

1. https://www.youtube.com/watch?v=TJ4jGyD-WCw
2. https://www.youtube.com/watch?v=dmt6_n7Sgcg
3. https://www.youtube.com/watch?v=_MQScnLXL0M
4. https://www.youtube.com/watch?v=3WXPanCq9LI
5. https://www.youtube.com/watch?v=fvjk7PlxAuo
6. http://www.me.umn.edu/coursesme2011/handouts/engg%20graphics.pdf
7. https://www.machinedesignonline.com

Course Outcomes

Following outcomes will be achieved:

1) Select and construct appropriate drawing scales, use drawing equipment's, and understand Indian Standards of engineering drawing

2) Draw views of given object and components 3) Sketch orthographic projections into isometric projections and vice versa.

3) Apply computer aided drafting tools to create 2D engineering drawings

APPLIED PHYSICS LAB-I

<table>
<tr><td rowspan="4">Subject Code
2001106</td><td colspan="3">Practical</td><td colspan="3">No of Periods in One Session : 45</td><td>Credits</td></tr>
<tr><td colspan="3">No. of Periods Per Week</td><td>Full Marks</td><td>:</td><td>50</td><td rowspan="3">02</td></tr>
<tr><td>L</td><td>T</td><td>P/S</td><td>Internal(PA)</td><td>:</td><td>15</td></tr>
<tr><td></td><td>-</td><td>03</td><td>External(ESE)</td><td>:</td><td>35</td></tr>
</table>

Course Objectives

Study of Applied Physics aims to give an understanding of physical world by observations and predictions. Concrete use of physical principles and analysis in various fields of engineering and technology is very prominence. The course aims to supplement the factual knowledge gained in the lecture by first hand manipulation of apparatus. This will develop scientific temper and help to apply the basic concepts and principles in solving engineering and technology based problems. In addition, students get necessary confidence in handling equipment and thus learn various skills in measurement.

List of Practical’s (To perform minimum 10 practical’s).

1. To measure length, radius of a given cylinder, a test tube and a beaker using a Vernier caliper and find volume of each object.
2. To determine diameter of a wire, a solid ball and thickness of cardboard using a screw gauge.
3. To determine radius of curvature of a convex and a concave mirror/surface using a spherometer.
4. To verify triangle and parallelogram law of forces.
5. To find the co-efficient of friction between wood and glass using a horizontal board.
6. To determine force constant of a spring using Hook’s Law.
7. To verify law of conservation of mechanical energy (PE to KE).
8. To find the moment of inertia of a flywheel.
9. To find the viscosity of a given liquid (Glycerin) by Stokes law.
10. To find the coefficient of linear expansion of the material of a rod.
11. To determine atmospheric pressure at a place using Fortin’s barometer.
12. To measure room temperature and temperature of a hot bath using mercury thermometer and convert it into different scales.

Learning Outcome:

After undergoing this lab work, the student will be able to:

- Select right kind of measuring tools (Meter scale, Vernier caliper, Screw gauge, Spherometer etc.) for determining dimensions of physical quantities and make measurements with accuracy and precision.
- Differentiate various shapes and determine dimensions of plane, curved and regular surfaces/bodies.
- Apply and Verify laws of forces and determine resultant force acting on a body.
- Appreciate role of friction and measure co-efficient of friction between different surfaces.
- Describe and verify Hook’s law and determine force constant of spring body.
- Identify various forms of energy, energy transformations and verify law of conservation of energy.
- Understand rotational motion and determine M.I. of a rotating body (flywheel)
- Understand Stokes law for viscous liquids and determine viscosity of a given liquid.
- Understand how materials expand on heating and determine linear expansion coefficient for

a given material rod. Understand working and use Fortin's barometers for determining pressure at a place.

- Understand use of thermometers to measure temperature under different conditions and different scales of temperature measurements.

SUGGESTED STUDENT ACTIVITES & STRATEGIES

Apart from classroom and laboratory learning following are the suggested student related activities which can be undertaken to accelerate the attainment of various outcomes of the course

a. Make survey of different physical products and compare the following points
    - Measurements of dimensions
    - Properties
    - Applications
b. Library survey regarding engineering materials/products used in different industries
c. Seminar on any relevant topic.

Teachers should use the following strategies to achieve the various outcomes of the course.

- Different methods of teaching and media to be used to attain classroom attention.
- Massive open online courses (MOOCs) may be used to teach various topics/sub topics.
- 15-20% of the topics which are relatively simpler of descriptive in nature should be given to the students for self-learning and assess the development of competency through classroom presentations.
- Micro-projects may be given to group of students for hand-on experiences.

References:

1. Text Book of Physics for Class XI& XII (Part-I, Part-II); N.C.E.R.T., Delhi
2. Comprehensive Practical Physics, Vol, I & II, JN Jaiswal, Laxmi Publications (P)Ltd.,
3. Practical Physics by C. L. Arora, S. Chand Publication.
4. e-books/e-tools/ learning physics software/YouTube videos/websites etc.

APPLIED CHEMISTRY LAB

Subject Code 2001107	Practical			No of Periods in One Session : 45			Credits
	No. of Periods Per Week			Full Marks	:	50	02
	L	T	P/S	Internal(PA)	:	15	
		-	03	External(ESE)	:	35	

Course Objectives:

There are numerous number of materials used in fabricating and manufacturing devices for the comfort of life. The selection, characterization and suitability assessment of natural raw materials essentially requires principles and concepts of Applied Chemistry for students. The course aims to supplement the factual knowledge gained in the lectures by first hand manipulation of processes and apparatus. This will develop scientific temper and help to apply the basic concepts and principles in solving technology based problems. In addition, students will get necessary confidence in handling equipments and thus learn various skills in measurement.

List of Practicals : Perform any 12 (twelve) Practicals :-

1. Preparation of 250ml N/10 Oxalic acid Solution.
2. Preparation of 250ml N/10 Sodium Carbonate Solution.
3. To determine the strength of Sodium Hydroxide Solution by Titrating against Oxalic Acid Solution.
4. Determination of Temporary Hardness of Tap Water.
5. Gravimetric Estimation of Moisture in given Coal Sample.
6. Determination of Percentage of Water of Crystallization in Barium Chloride.
7. Preparation of Cupric Oxide from Copper Sulphate.
8. Preparation of Barium Sulphate from Barium Chloride.

9-11. Qualitative Analysis of Three Solutions containing One Basic and One Acid radicals Listed below.

Basic radicals – NH_4^+, Pb^{+2}, Cu^{+2},Ni^{+2}, Zn^{+2}, Fe^{+2}.

Acid radicals – Cl^-, Br^-, I^-, NO_3^-, CO_3^{-2}, SO_4^{-2}.

12. Determination of Viscosity of Lubricating Oil Using Ostwald Viscometer.
13. To Verify Faradays First Law of Electrolysis.
14. To determine pH of given solution by pH meter.
15. Prepare Phenol Formaldehyde Resin (Bakelite)
16. To Determine Dissolved Oxygen in given Sample of Water.

Learning Outcomes:

At the end of the course student will be able to

- To express quantitative measurements accurately.
- To practice and adapt good measuring techniques.
- To use various apparatus for precise measurements.
- To understand and differentiate different methods of quantitative analysis.
- To know and understand principles of quantitative analysis using instruments.

- To construct different electrochemical cells used in developing batteries.
- To understand and appreciate methods of corrosion abetments.

Reference Books:

1. Text Book of Chemistry for Class XI & XII (Part-I, Part-II); N.C.E.R.T., Delhi, 2017-18.
2. Dr. G. H. Hugar and Prof A. N. Pathak, Applied Chemistry Laboratory Practices, Vol. I and Vol. II, NITTTR, Chandigarh, Publications, 2013-14.
3. Agnihotri, Rajesh, Chemistry for Engineers, Wiley India Pvt.Ltd., 2014.
4. Jain & Jain, Engineering Chemistry, Dhanpat Rai and Sons; New Delhi, 2015.

COMMUNICATION SKILLS IN ENGLISH LAB

Subject Code 2001108	Practical			No of Periods in One Session : 45			Credits
	No. of Periods Per Week			Full Marks	:	50	02
	L	T	P/S	Internal(PA)	:	15	
		-	03	External(ESE)	:	35	

Course Objectives:

Communication skills play an important role in career development. This lab course aims at actively involving students in various activities to improve their communication skills with an emphasis on developing personality of the students. Thus, the objectives of this course are:

1. To develop listening skills for enhancing communication.
2. To develop speaking skills with a focus on correct pronunciation and fluency.
3. To introduce the need for Personality development- Focus will be on developing certain qualities which will help students in handling personal and career challenges, leadership skills etc. For that purpose group discussion, extempore and other activities should be conducted during lab classes.

Course Content:

UNIT- 1 Listening Skills

Listening Process and Practice: Introduction to recorded lectures, poems, interviews and speeches, listening tests.

UNIT- II Introduction to Phonetics

Sounds: consonant, vowel, diphthongs, etc. transcription of words (IPA), weak forms, syllable division, word stress, intonation, voice etc.

UNIT- III Speaking Skills

Standard and formal speech: Group discussion, oral presentations, public speaking, extempore speech, business presentations conversation practice and role playing, mock interviews etc.

UNIT- IV Building Vocabulary

Etymological study of words and construction of words, phrasal verbs, idioms and phrases.

Jargon/ Register related to organizational set up, word exercises and word games to enhance self-expression and vocabulary of participants.

Recommended Readings:

1. Daniel Jones. *The Pronunciation of English.* Cambridge: Cambridge University Press, 1956.
2. James Hartman& et al. Ed. *English Pronouncing Dictionary*. Cambridge: Cambridge University Press 2006.
3. Kulbhushan Kumar, Effective Communication Skills, Khanna Publishing House, New Delhi (Revised Ed. 2018)
4. J.D.O'Connor. *Better English Pronunciation.* Cambridge: Cambridge University Press, 1980.
5. Lindley Murray. *An English Grammar: Comprehending Principles and Rules.* London: Wilson and Sons, 1908.
6. Margaret M. Maison. *Examine your English.* Orient Longman: New Delhi, 1964.
7. J.Sethi & et al. *A Practice Course in English Pronunciation*. New Delhi: Prentice Hall, 2004.
8. Pfeiffer, William Sanborn and T.V.S Padmaja. *Technical Communication: A Practical Approach*. 6th ed. Delhi: Pearson, 2007.

Learning Outcome:

- At the end of this course the students will be able to communicate effectively with an increase in their confidence to read, write and speak English fluently.
- They will also demonstrate a significant increase in word power.
- The variety of exercises and activities that will be conducted in the Language Lab will devel- op their skills needed to participate in a conversation like listening carefully and respectfully to others' viewpoints; articulating their own ideas and questions clearly and over all students will be able to prepare, organize, and deliver an engaging oral presentation.
- They will also develop non-verbal communication such as proper use of body language and gestures.

ENGINEERING WORKSHOP PRACTICE

<table>
<tr><td rowspan="4">Subject Code
2001109</td><td colspan="3">Term Work</td><td colspan="3">No of Periods in One Session : 90</td><td>Credits</td></tr>
<tr><td colspan="3">No. of Periods Per Week</td><td>Full Marks</td><td>:</td><td>25</td><td rowspan="3">02</td></tr>
<tr><td>L</td><td>T</td><td>P/S</td><td>Internal(PA)</td><td>:</td><td>07</td></tr>
<tr><td></td><td>-</td><td>06</td><td>External(ESE)</td><td>:</td><td>18</td></tr>
</table>

Course Objectives:

- To understand basic engineering processes for manufacturing and assembly.
- To understand, identify, select and use various marking, measuring, and holding, striking and cutting tools and equipment's
- To understand and interpret job drawings, produce jobs, and inspect the job for specified dimensions
- To understand the various types of wiring systems and acquire skills in house wiring
- To understand, operate, control different machines and equipment's adopting safety practices Course Content:

Course Content :

I **Carpentry:** i) Demonstration of different wood working tools / machines. **[16]**

ii) Demonstration of different wood working processes, like plaining, marking, chiseling, grooving, turning of wood etc. iii) One simple job involving any one joint like mortise and tenon dovetail, bridle, half lap etc.

II **Fitting:** i) Demonstration of different fitting tools and drilling machines and power tools **[16]**

ii) Demonstration of different operations like chipping, filing, drilling, tapping, sawing, cutting etc. iii) One simple fitting job involving practice of chipping, filing, drilling, tapping, cutting etc

III **Welding:** i) Demonstration of different welding tools / machines. ii) Demonstration on Arc **[16]**

15]Welding, Gas Welding, MIG, MAG welding, gas cutting and rebuilding of broken parts with welding. iii) One simple job involving butt and lap joint

IV **Sheet Metal Working:** i) Demonstration of different sheet metal tools / machines. **[16]**

ii) Demonstration of different sheet metal operations like sheet cutting, bending, edging, end curling, lancing, soldering, brazing, and riveting. iii) One simple job involving sheet metal operations and soldering and riveting.

V **Electrical House Wiring:** Practice on simple lamp circuits (i) one lamp controlled by one **[16]**

switch by surface conduit wiring, (ii) Lamp circuits- connection of lamp and socket by separate switches, (iii) Connection of Fluorescent lamp/tube light, (iv) simple lamp circuits-in- stall bedroom lighting. And (v) Simple lamp circuits- install stair case wiring.

VI **Demonstration:** i) Demonstration of measurement of Current, Voltage, Power and Energy. **[10]**

ii) Demonstration of advance power tools, pneumatic tools, electrical wiring tools and accessories. iii) Tools for Cutting and drilling

References:

1. S.K. Hajara Chaudhary, Workshop Technology, Media Promoters and Publishers, New Delhi, 2015
2. B.S. Raghuwanshi, Workshop Technology, Dhanpat Rai and sons, New Delhi 2014
3. K. Venkat Reddy, Workshop Practice Manual, BS Publications, Hyderabad 2014
4. Kents Mechanical Engineering Hand book, John Wiley and Sons, New York Course outcomes

At the end of the course, the student will be able to:

CO1	Acquire skills in basic engineering practice to identify, select and use various marking, measuring, and holding, striking and cutting tools & equipment's and machines
CO2	Understand job drawing and complete jobs as per specifications in allotted time
CO3	Inspect the job for the desired dimensions and shape
CO4	Operate, control different machines and equipment's adopting safety practices

SPORTS AND YOGA

<table>
<tr><td rowspan="4">Subject Code
2001110</td><td colspan="3">Term Work</td><td colspan="3">No of Periods in One Session : 30</td><td>Credits</td></tr>
<tr><td colspan="3">No. of Periods Per Week</td><td>Full Marks</td><td>:</td><td>25</td><td rowspan="3">02</td></tr>
<tr><td>L</td><td>T</td><td>P/S</td><td>Internal(PA)</td><td>:</td><td>07</td></tr>
<tr><td></td><td>-</td><td>02</td><td>External(ESE)</td><td>:</td><td>18</td></tr>
</table>

Course Objectives:

- To make the students understand the importance of sound health and fitness principles as they relate to better health.
- To expose the students to a variety of physical and yogic activities aimed at stimulating their continued inquiry about Yoga, physical education, health and fitness.
- To create a safe, progressive, methodical and efficient activity based plan to enhance improvement and minimize risk of injury.
- To develop among students an appreciation of physical activity as a lifetime pursuit and a means to better health.

Course Content:

- **Introduction to Sports**
    - Meaning & Definition of Sports
    - Aims & Objectives of Physical Education
    - Awards and Honours in the Field of Sports in India (Dronacharya Award, Arjuna Award, Dhayanchand Award, Rajiv Gandhi Khel Ratna Award etc.)
- **Physical Fitness, Wellness & Lifestyle**
    - Meaning & Importance of Physical Fitness & Wellness
    - Components of Physical Fitness
    - Components of Wellness
    - Preventing Health Threats through Lifestyle Change
    - Concept of Positive Lifestyle
- **Postures**
    - Meaning and Concept of Postures.
    - Causes of Bad Posture.
    - Concept & Advantages of Correct Posture.
- **Yoga**
    - Meaning & Importance of Yoga
    - Elements of Yoga
    - Introduction - Asanas, Pranayama, Meditation & Yogic Kriyas
    - Yoga for Concentration & Related Asanas (Sukhasana; Tadasana; Padmasana & Sha-shankasana)

- **Yoga & Lifestyle**
  - Asanas as Preventive Measures.
  - Hypertension: Tadasana, Vajrasana, Pavan Muktasana, Ardha Chakrasana, Bhujangasana, Sharasana.
  - Obesity: Procedure, Benefits & Contraindications for Vajrasana.
  - Back Pain: Tadasana, Ardh Matsyendrasana, Bhujangasana.
  - Diabetes: Procedure, Benefits & Contraindications for Bhujangasana, Paschimottasana, Ardh Matsyendrasana.
  - Asthma: Procedure, Benefits & Contraindications for Sukhasana, Bhujangasana , Matsyasana.
- **Psychology & Sports**
  - Psychological Benefits of Exercise.
  - Anxiety & Fear and Its Effects on Sports Performance.
  - Motivation, Its types & Techniques.
  - Understanding Stress & Coping Strategies.
  - **Sports / Games**

    Following sub topics related to any one Game/Sport of choice of student out of: Athletics, Badminton, Chess, Cricket, Kabaddi, Table Tennis, Volleyball, Yoga etc.

    - History of the Games/Sport.
    - Latest General Rules of the Games/Sports.
    - Specifications of Play Fields and Related Sports Equipment.
    - Important Tournaments and Venues.
    - Sports Personalities.

References:

1. Modern Trends and Physical Education by Prof. Ajmer Singh.
2. Light On Yoga By B.K.S. Iyengar.
3. Health and Physical Education – NCERT (11th and 12th Classes)

Course Outcomes:

On successful completion of the course the students will be able to:

(i) Practice Physical activities and Hatha Yoga focusing on Yoga for strength, flexibility, and relaxation.

(ii) Learn techniques for increasing concentration and decreasing anxiety which leads to stronger academic performance.

(iii) Learn breathing exercises and healthy fitness activities

(iv) Understand basic skills associated with yoga and physical activities including strength and flexibility, balance and coordination.

(v) Perform Yoga movements in various combination and forms.

(vi) Assess current personal fitness levels.

(vii) Identify opportunities for participation in Yoga and Sports activities.

(viii) Develop understanding of health-related fitness components: cardiorespiratory endurance, flexibility and body composition etc.

(ix) Improve personal fitness through participation in Sports and Yogic activities.

(x) Develop understanding of psychological problems associated with the age and lifestyle.

(xi) Demonstrate an understanding of sound nutritional practices as related to health and physical performance.

(xii) Assess Yoga activities in terms of fitness value.

(xiii) Identify and apply injury prevention principles related to Yoga and physical fitness activities.

(xiv) Understand and correctly apply biomechanical and physiological principles related to exercise and training.

C / KYP / IT ESSENTIAL / PYTHON / OTHERS

<table>
<tr><td rowspan="4">Subject Code
2001111</td><td colspan="3">Term Work</td><td colspan="3">No of Periods in One Session : 30</td><td>Credits</td></tr>
<tr><td colspan="3">No. of Periods Per Week</td><td>Full Marks</td><td>:</td><td>50</td><td rowspan="3">01</td></tr>
<tr><td>L</td><td>T</td><td>P/S</td><td>Internal(PA)</td><td>:</td><td>15</td></tr>
<tr><td></td><td>-</td><td>02</td><td>External(ESE)</td><td>:</td><td>35</td></tr>
</table>

STATE BOARD OF TECHNICAL EDUCATION, BIHAR

Scheme of Teaching and Examinations for
IInd Semester
(Effective from Session 2020-21)

THEORY

Sr. No.	SUBJECTS	SUBJECT CODE	TEACHING SCHEME Periods per Week			EXAMINATION – SCHEME							Credits
			L	T	L+T	Hours of Exam.	Teacher's Assessment (TA) Marks (A)	Class Test(CT) Marks (B)	End Semester Exam. (ESE) Marks (C)	Total Marks (A+B+C)	Pass Marks ESE	Pass Marks in the Subject	
1.	Mathematics-II	2002201	03	01	04	03	10	20	70	100	28	40	04
2.	Applied Physics-II	2002202	02	01	03	03	10	20	70	100	28	40	03
3.	Introduction to IT Systems	2002203	02	01	03	03	10	20	70	100	28	40	02
4.	Fundamental of Electrical & Electronics Engg.	2002204	02	01	03	03	10	20	70	100	28	40	03
5.	Engg. Mechanics	2002205	02	01	03	03	10	20	70	100	28	40	03
		Total:-	**11**	**05**	**16**				**350**	**500**			**15**

PRACTICAL

Sr. No.	SUBJECTS	SUBJECT CODE	TEACHING SCHEME Periods per Week	EXAMINATION – SCHEME Hours of Exam.	Practical Internal(PA)	Practical External(ESE)	Total Marks	Pass Marks in the Subject	Credits
6.	Applied Physics Lab-II	2002206	02	03	15	35	50	20	01
7.	Introduction to IT Systems Lab	2002207	04	03	15	35	50	20	02
8.	Fundamental of Electrical & Electronics Engg. Lab	2002208	04	03	15	35	50	20	01
9.	Engg. Mechanics Lab	2002209	03	03	15	35	50	20	02
		Total:-	**13**				**200**		**06**

TERM WORK

Sr. No.	SUBJECTS	SUBJECT CODE	TEACHING SCHEME Periods per week	EXAMINATION – SCHEME Marks of Internal (PA)	Marks of External (ESE)	Total Marks	Pass Marks in the Subject	Credits
10.	Course under MOOCS / SWAYAM / ETC / Others	2002210	-	06	14	20	08	02
11.	KYP/IT Essential/Python/Others	2002211	-	06	14	20	08	01
12.	Environmental Science	2002212	02	10	-	10	04	-
		Total:-	**02**			**50**		**03**
Total Periods per week Each of duration One Hours 31						**Total Marks = 750**		**24**

MATHEMATICS - II

Subject Code	Theory			No of Periods in One Session : 60			Credits
	No. of Periods Per Week			Full Marks	:	100	
	L	T	P/S	ESE	:	70	04
2002201	03	01	-	TA	:	10	
	-	-	-	CT	:	20	

Course Objectives:

This course is designed to give a comprehensive coverage at an introductory level to the subject of Differential Calculus, Integral Calculus,First Order Differential Equations and Basic elements of vector algebra.

Course Content:

UNIT - I: Differential Calculus [18]

Definition of function; Types of function & simple examples, Concept of limits. Four standard limits

$$\lim_{x \to a} \frac{x^n - a^n}{x - a}, \quad \lim_{x \to 0} \frac{\sin x}{x}, \quad \lim_{x \to a} \left(\frac{a^x - 1}{x}\right) \text{ and } \lim_{x \to a} (1 + x)^{\frac{1}{x}}$$

Concept of Continuity (Simple Problems)

Differentiation bydefinition of x^n, $\sin x$ $\cos x$, $\tan x$, e^x and $\log_a x$. Differentiation of sum, product and quotient of functions. Differentiation of function of a function. Differentiation of trigonometric and inverse trigonometric functions, Logarithmic differentiation, Exponentialfunctions. Differentiation of implicit and Parametric function. Differentiation of one function with respect to another function.

UNIT - II: Integral Calculus [18]

Integration as inverse operation of differentiation. Simple integration by transformation, by substitution, by parts andbypartialfractions(forlinearfactorsonly).Definite Integration & its properties,simple problems.Applications of integration for (i) Simple problem on evaluation of area bounded by a curve and axes. (ii) Area bounded by two curves .(Simple problems).

UNIT-III: Differential Equations [08]

Definition of differential equations. Order and degree of a differential equation.Formation of differential equation.Solution of first order and first degree differential equation by variable separation method (simple problems).MATLAB – Simple Introduction.

UNIT - IV: Vector Algebra [16]

Definition, notation and rectangular resolution of a vector. Addition and subtraction of vectors. Scalar and vector products of 2 vectors. Simple problems related to work, moment and angular velocity.

References:

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, New Delhi, 40th Edition, 2007.
2. S.S. Sabharwal, Sunita Jain, Eagle Parkashan, Applied Mathematics, Vol. I & II, Jalandhar.
3. Comprehensive Mathematics, Vol. I & II by Laxmi Publications, Delhi.
4. Mathematics today XI & XII (Part I & II) by Lalji Prasad (Paramount Publication, GovindMitra Road)
5. A Text Book of Mathematics-XI & XII (Vol-1 & Vol-2) - by K.C. Sinha- Rastogi Publication, Meerut.

Course Outcomes:

By the end of the course the students are expected to learn

(i) the cumulative effect of the original quantity or equation is theIntegration

(ii) Tell the difference between a resultant and a concurrent force to model simple physical problems in the form of a differential equation, analyze and interpret the solutions.

APPLIED PHYSICS -II

Subject Code 2002202	Theory			No of Periods in One Session : 45			Credits
	No. of Periods Per Week			Full Marks	:	100	03
	L	T	P/S	ESE	:	70	
	02	01	-	TA	:	10	
	-	-	-	CT	:	20	

Course Objectives :-

Applied Physics aims to give an understanding of this world both by observation and by prediction of the way in which objects behave. Concrete use of physical principles and analysis in various fields of engineering and technology are given prominence in the course content. The course will help the diploma engineers to apply the basic concepts and principles to solve broad-based engineering problems and to understand different technology based applications.

Teaching Approach :-

Teachers should give examples from daily routine as well as, engineering/technology applications on various concepts and principles in each topic so that students are able to understand and grasp these concepts and principles. In all contents, SI units should be followed. Use of demonstration can make the subject interesting and develop scientific temper in the students. Student activities should be planned on all the topics.

Activity- Theory - Demonstrate/practice approach may be followed throughout the course so that learning may be outcome and employability based.

Course Content :-

UNIT - 1: Wave motion and its applications [07]

Wave motion, transverse and longitudinal waves with examples, definitions of wave velocity, frequency and wave length and their relationship, Sound and light waves and their properties, wave equation ($y = r \sin \omega t$) amplitude, phase, phase difference, principle of superposition of waves and beat formation.

Simple Harmonic Motion (SHM): definition, expression for displacement, velocity, acceleration, time period, frequency etc. Simple harmonic progressive wave and energy transfer, study of vibration of cantilever and determination of its time period, Free, forced and resonant vibrations with examples.

Acoustics of buildings – reverberation, reverberation time, echo, noise, coefficient of absorption of sound, methods to control reverberation time and their applications, Ultrasonic waves – Introduction and properties, engineering and medical applications of ultrasonic.

UNIT - 2: Optics [07]

Basic optical laws; reflection and refraction, refractive index, Images and image formation by mirrors, lens and thin lenses, lens formula, power of lens, magnification and defects. Total internal reflection, Critical angle and conditions for total internal reflection, applications of total internal reflection in optical fiber.

Optical Instruments; simple and compound microscope, astronomical telescope in normal adjustment, magnifying power, resolving power, uses of microscope and telescope, optical projection systems.

UNIT - 3: Electrostatics **[06]**

Coulombs law, unit of charge, Electric field, Electric lines of force and their properties, Electric flux, Electric potential and potential difference, Gauss law: Application of Gauss law to find electric field intensity of straight charged conductor, plane charged sheet and charged sphere. Capacitor and its working, Types of capacitors, Capacitance and its units. Capacitance of a parallel plate capacitor, Series and parallel combination of capacitors (related numerical), dielectric and its effect on capacitance, dielectric break down.

UNIT - 4: Current Electricity **[06]**

Electric Current and its units, Direct and alternating current, Resistance and its units, Specific resistance, Conductance, Specific conductance, Series and parallel combination of resistances. Factors affecting resistance of a wire, carbon resistances and color coding.

Ohm's law and its verification, Kirchhoff's laws, Wheatstone bridge and its applications (slide wire bridge only), Concept of terminal potential difference and Electro motive force (EMF) Heating effect of current, Electric power, Electric energy and its units (related numerical problems), Advantages of Electric Energy over other forms of energy.

UNIT - 5: Electromagnetism **[06]**

Types of magnetic materials; diamagnetic , Paramagnetic and ferromagnetic with their properties, Magnetic field and its units, magnetic intensity, magnetic lines of force, magnetic flux and units, magnetization. Concept of electromagnetic induction, Faraday's Laws, Lorentz force (force on moving charge in magnetic field). Force on current carrying conductor, force on rectangular coil placed in magnetic field. Moving coil galvanometer; principle, construction and working, Conversion of a galvanometer into ammeter and voltmeter.

UNIT - 6: Semiconductor Physics **[06]**

Energy bands in solids, Types of materials (insulator, semi-conductor, conductor), intrinsic and extrinsic semiconductors, p-n junction, junction diode and V-I characteristics, types of junction diodes. Diode as rectifier – half wave and full wave rectifier (centre taped).

Transistor; description and three terminals, Types- p-n-p and n-p-n, some electronic applications (list only). Photocells, Solar cells; working principle and engineering applications.

UNIT - 7: Modern Physics **[07]**

Lasers: Energy levels, ionization and excitation potentials; spontaneous and stimulated emission; population inversion, pumping methods, optical feedback, Types of lasers; Ruby, He-Ne and semiconductor, laser characteristics, engineering and medical applications of lasers.

Fiber Optics: Introduction to optical fibers, light propagation, acceptance angle and numerical aperture, fiber types, applications in; telecommunication, medical and sensors.

Nano-science and Nanotechnology: Introduction, nano-particles and nano-materials, properties at nano-scale, nanotechnology, nanotechnology based devices and applications.

Learning Outcome:

After undergoing this subject, the student will be able to;

a) Describe waves and wave motion, periodic and simple harmonic motions and solve simple problems. Establish wave parameters: frequency, amplitude, wavelength, and velocity and able to explain diffraction, interference, polarization of waves.

b) Explain ultrasonic waves and engineering, medical and industrial applications of Ultrasonics. Apply acoustics principles to various types of buildings for best sound effect.

c) State basic optical laws, establish the location of the images formed by mirrors and thin con- verging lens**,** design and assemble microscope using lenses combination.

d) Describe refractive index of a liquid or a solid and will be able to explain conditions for total internal reflection.

e) Define capacitance and its unit, explain the function of capacitors in simple circuits, and solve simple problems.

f) Differentiate between insulators, conductors and semiconductors, and define the terms: potential, potential difference, electromotive force.

g) Express electric current as flow of charge, concept of resistance, measure of the parameters: electric current, potential difference, resistance.

h) List the effects of an electric current and its common applications, State Ohm's law, calculate the equivalent resistance of a variety of resistor combinations, distinguish between AC and DC currents, determine the energy consumed by an appliance,

i) State the laws of electromagnetic induction, describe the effect on a current-carrying conductor when placed in a magnetic field.

j) Explain the operation of appliances like moving coil galvanometer, simple DC motors.

k) Apply the knowledge of diodes in rectifiers, power adapters and various electronic circuits. Use the knowledge of semiconductors in various technical gadgets like mobile phones, computers, LED, photocells, solar lights etc.

l) Illustrate the conditions for light amplification in various LASER and laser based instruments and optical devices.

m) Appreciate the potential of optical fiber in fields of medicine and communication.

n) Express importance of nanoscience and nanotechnology and impact of nanotechnology to the society.

References:

1. Text Book of Physics for Class XI& XII (Part-I, Part-II); N.C.E.R.T., Delhi
2. Applied Physics, Vol. I and Vol. II, TTTI Publications, Tata McGraw Hill, Delhi
3. Concepts in Physics by HC Verma, Vol. I & II, Bharti Bhawan Ltd. New Delhi
4. Engineering Physics by PV Naik, Pearson Education Pvt. Ltd, New Delhi.
5. Modern approach to Applied Physics-I and II, AS Vasudeva, Modern Publishers.
6. A Textbook of Optics, N Subramanyam, Brij Lal, MN Avahanulu, S Chand and Company Ltd.
7. Introduction to Fiber Optics, Ajoy Ghatak and K Thyagarajan, Cambridge University Press India Pvt. Ltd, New Delhi.
8. Nanoscience and Nanotechnology, KK Choudhary, Narosa Publishing House, Pvt. Ltd. New Delhi.
9. Nanotechnology: Importance and Applications, M.H. Fulekar, IK International Publishing House Pvt. Ltd, New Delhi.
10. e-books/e-tools/ learning physics software/websites etc.

INTRODUCTION TO IT SYSTEMS

Subject Code	Theory			No of Periods in One Session : 45			Credits
2002203	No. of Periods Per Week			Full Marks	:	100	02
	L	T	P/S	ESE	:	70	
	02	01	-	TA	:	10	
	-	-	-	CT	:	20	

Course Objectives:-

This course is intended to make new students comfortable with computing environment Learning basic computer skills, Learning basic application software tools, Understanding Computer Hardware, Cyber security awareness

Course Content:-

UNIT 1: Basic Internet skills: Understanding browser, efficient use of search engines, awareness about Digital India portals (state and national portals) and college portals.

General understanding of various computer hardware components – CPU, Memory, Display, Keyboard, Mouse, HDD and other Peripheral Devices.

UNIT 2: OS Installation (Linux and MS Windows), Unix Shell and Commands, vi editor.

UNIT 3: HTML4, CSS, making basic personal webpage.

UNIT 4: Office Tools: Open Office Writer, Open Office Spreadsheet (Calc), Open Office Impress.

UNIT 5: Information security best practices. Class lectures will only introduce the topic or demonstrate the tool, actual learning will take place in the Lab by practicing regularly.

Suggested Lab Work:

This is a skill course. Topics/concepts taught in the class should be practiced in the Lab same week and practiced regularly during the semester till student becomes confident about it. This course is all about some theory and a lot of practice.

References:

- R.S. Salaria, Computer Fundamentals, Khanna Publishing House
- Ramesh Bangia, PC Software Made Easy – The PC Course Kit, Khanna Publishing House
- Online Resources, Linux man pages, Wikipedia
- Mastering Linux Shell Scripting: A practical guide to Linux command-line, Bash scripting, and Shell programming, by Mokhtar Ebrahim, Andrew Mallett

Course outcomes:

At the end of the course student will be able to comfortably work on computer, install and configure OS, assemble a PC and connect it to external devices, write documents, create worksheets, prepare presentations, protect information and computers from basic abuses/ attacks.

FUNDAMENTALS OF ELECTRICAL AND ELECTRONICS ENGINEERING

<table>
<tr><td rowspan="5">Subject Code
2002204</td><td colspan="3">Theory</td><td colspan="3">No of Periods in One Session : 45</td><td>Credits</td></tr>
<tr><td colspan="3">No. of Periods Per Week</td><td>Full Marks</td><td>:</td><td>100</td><td rowspan="4">03</td></tr>
<tr><td>L</td><td>T</td><td>P/S</td><td>ESE</td><td>:</td><td>70</td></tr>
<tr><td>02</td><td>01</td><td>-</td><td>TA</td><td>:</td><td>10</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>CT</td><td>:</td><td>20</td></tr>
</table>

Course Objectives:-

To provide basic knowledge of the different elements and concepts of electrical engineering field and to learn basic concepts of various active and passive electronic components, Signals, Op-Amp and their applications, Digital Electronics and their applications to help students deal with electrical and electronics engineering principles and applications in industrial processes of different fields.

Course Content:-

UNIT- I <u>Overview of Electronic Components & Signals:</u>

Passive Active Components: Resistances, Capacitors, Inductors. Basic Concept of Diodes, Transistors, FET, MOS and CMOS and their Applications. Signals: DC / AC, voltage / current, periodic / non-periodic signals, Ideal / non-ideal voltage / current sources, independent / dependent voltage current sources.

UNIT- II <u>Overview of Analog Circuits:</u>

Operational Amplifiers-Ideal Op-Amp, Practical op amp, Open loop and closed loop configurations, Application of Op-Amp as amplifier, adder, differentiator and integrator.

UNIT- III <u>Overview of Digital Electronics:</u>

Introduction to Boolean Algebra, Electronic Implementation of Boolean Operations, Gates-Functional Block Approach,

UNIT - IV <u>Electric and Magnetic Circuits:</u>

EMF, Current, Potential Difference, Power and Energy; M.M.F, magnetic force, permeability, hysteresis loop, reluctance, leakage factor and BH curve; Electromagnetic induction, Faraday's laws of electromagnetic induction, Lenz's law; Dynamically induced emf; Statically induced emf; Equations of self and mutual inductance; Analogy between electric and magnetic circuits.

UNIT - V <u>A.C. Circuits:</u>

Cycle, Frequency, Periodic time, Amplitude, Angular velocity, RMS value, Average value, Form Factor Peak Factor, impedance, phase angle, and power factor KCL and KVL Mathematical and phasor representation of alternating emf and current; Voltage and Current relationship in Star and Delta connections; A.C in resistors, inductors and capacitors; A.C in R-L series, R-C series, R-L-C series Circuits.

UNIT VI <u>Transformer and Machines:</u> General construction and principle of different type of transformers; Emf equation and transformation ratio of transformers; Auto transformers; Construction and Working principle of motors; Basic equations and characteristic of motors.

References:

1. Ritu Sahdev, Basic Electrical Engineering, Khanna Publishing House
2. Mittle and Mittal, Basic Electrical Engineering, McGraw Education, New Delhi, 2015, ISBN : 978-0-07-0088572-5
3. Saxena, S. B. Lal, Fundamentals of Electrical Engineering, Cambridge University Press, latest edition ISBN : 9781107464353
4. Theraja, B. L., Electrical Technology Vol – I, S. Chand Publications, New Delhi, 2015, ISBN: 9788121924405
5. Theraja, B. L., Electrical Technology Vol – II, S. Chand Publications, New Delhi, 2015, ISBN: 9788121924375
6. Jegathesan, V., Basic Electrical and Electronics Engineering, Wiley India, New Delhi, 2015, ISBN : 97881236529513
7. Sedha, R.S., A text book of Applied Electronics, S.Chand, New Delhi, 2008, ISBN-13: 978-8121927833
8. Malvino, Albert Paul, David, Electronics Principles, McGraw Hill Education, New Delhi,2015, ISBN-13**:** 0070634244-978
9. Mehta, V.K., Mehta, Rohit, Principles of Electronics, S. Chand and Company, New Delhi, 2014, ISBN-13-9788121924504
10. Bell Devid, Fundamental of Electronic Devices and Circuits, Oxford University Press, New Delhi 2015 ISBN : 9780195425239

ENGINEERING MECHANICS

Subject Code 2002205	Theory			No of Periods in One Session : 45			Credits
	No. of Periods Per Week			Full Marks	:	100	03
	L	T	P/S	ESE	:	70	
	02	01	-	TA	:	10	
	-	-	-	CT	:	20	

Course Objectives:-

Following are the objectives of this course:

1) To obtain resultant of various forces
2) To calculate support reactions through conditions of equilibrium for various structures
3) To understand role of friction in equilibrium problems
4) To know fundamental laws of machines and their applications to various engineering problems

Course Contents:-

UNIT – I Basics of mechanics and force system [11]

Significance and relevance of Mechanics, Applied mechanics, Statics, Dynamics. Space, time, mass, particle, flexible body and rigid body. Scalar and vector quantity, Units of measurement (SI units) - Fundamental units and derived units.

Force – unit, representation as a vector and by Bow's notation, characteristics and effects of a force, Principle of transmissibility of force, Force system and its classification.

Resolution of a force - Orthogonal components of a force, moment of a force, Varignon's Theorem.

Composition of forces – Resultant, analytical method for determination of resultant for concurrent, non-concurrent and parallel co-planar force systems – Law of triangle, parallelogram and polygon of forces.

UNIT– II Equilibrium [10]

Equilibrium and Equilibrant, Free body and Free body diagram, Analytical and graphical methods of analysing equilibrium Lami's Theorem – statement and explanation, Application for various engineering problems. Types of beam, supports (simple, hinged, roller and fixed) and loads acting on beam (vertical and inclined point load, uniformly distributed load, couple), Beam reaction for cantilever, simply supported beam with or without overhang – subjected to combination of Point load and uniformly distributed load. Beam reaction graphically for simply supported beam subjected to vertical point loads only.

UNIT– III Friction [06]

Friction and its relevance in engineering, types and laws of friction, limiting equilibrium, limiting friction, co-efficient of friction, angle of friction, angle of repose, relation between co-efficient of friction and angle of friction.

Equilibrium of bodies on level surface subjected to force parallel and inclined to plane. Equilibrium of bodies on inclined plane subjected to force parallel to the plane only.

UNIT– IV Centroid and centre of gravity **[08]**

Centroid of geometrical plane figures (square, rectangle, triangle, circle, semicircle, quarter circle) Centroid of composite figures composed of not more than three geometrical figures Centre of Gravity of simple solids (Cube, cuboid, cone, cylinder, sphere, hemisphere) Centre of Gravity of composite solids composed of not more than two simple solids.

UNIT – V Simple lifting machine **[10]**

Simple lifting machine, load, effort, mechanical advantage, applications and advantages. Velocity ratio, efficiency of machines, law of machine. Ideal machine, friction in machine, maximum Mechanical advantage and efficiency, reversible and non-reversible machines, conditions for reversibility Velocity ratios of Simple axle and wheel, Differential axle and wheel, Worm and worm wheel, Single purchase and double purchase crab winch, Simple screw jack, Weston's differential pulley block, geared pulley block.

Suggested Learning Resources:

1. D.S. Bedi, Engineering Mechanics, Khanna Publications, New Delhi (2008)
2. Khurmi, R.S., Applied Mechanics, S. Chand & Co. New Delhi.
3. Bansal R K, A text book of Engineering Mechanics, Laxmi Publications.
4. Ramamrutham, Engineering Mechanics, S. Chand & Co. New Delhi.
5. Dhade, Jamadar & Walawelkar, Fundamental of Applied Mechanics, Pune Vidhyarthi Gruh.
6. Ram, H. D.; Chauhan, A. K., Foundations and Applications of Applied Mechanics, Cam- bridge University Press.
7. Meriam, J. L., Kraige, L.G., Engineering Mechanics- Statics, Vol. I, Wiley Publication, New Delhi.

Course outcomes:

After completing this course, student will be able to:

1. Identify the force systems for given conditions by applying the basics of mechanics.
2. Determine unknown force(s) of different engineering systems.
3. Apply the principles of friction in various conditions for useful purposes.
4. Find the centroid and centre of gravity of various components in engineering systems.
5. Select the relevant simple lifting machine(s) for given purposes.

APPLIED PHYSICS LAB II

<table>
<tr><td rowspan="5">Subject Code
2002206</td><td colspan="3">Practical</td><td colspan="3">No of Periods in One Session : 30</td><td>Credits</td></tr>
<tr><td colspan="3">No. of Periods Per Week</td><td>Full Marks</td><td>:</td><td>50</td><td rowspan="4">01</td></tr>
<tr><td>L</td><td>T</td><td>P/S</td><td>Internal(PA)</td><td>:</td><td>15</td></tr>
<tr><td>-</td><td>-</td><td>02</td><td>External(ESE)</td><td>:</td><td>35</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>-</td><td>:</td><td>-</td></tr>
</table>

Course Objectives:

Concrete use of physical principles and analysis in various fields of engineering and technology is very prominence. The course aims to supplement the factual knowledge gained in the lecture by first hand manipulation of apparatus. This will develop scientific temper and help to apply the basic concepts and principles in solving engineering and technology based problems. In addition, students get necessary confidence in handling equipment and thus learn various skills in measurement.

List of Practical's (To perform minimum 12 Practical's)

1. To determine and verify the time period of a cantilever.
2. To determine velocity of ultrasonic in different liquids using ultrasonic interferometer.
3. To verify laws of reflection from a plane mirror/ interface.
4. To verify laws of refraction (Snell's law) using a glass slab.
5. To determine focal length and magnifying power of a convex lens.
6. To verify Ohm's law by plotting graph between current and potential difference.
7. To verify laws of resistances in series and parallel combination.
8. To find the frequency of AC main using electrical vibrator.
9. To verify Kirchhoff's law using electric circuits.
10. To study the dependence of capacitance of a parallel plate capacitor on various factors and determines permittivity of air at a place.
11. To find resistance of a galvanometer by half deflection method.
12. To convert a galvanometer into an ammeter.
13. To convert a galvanometer into a voltmeter.
14. To draw V-I characteristics of a semiconductor diode (Ge, Si) and determine its knee voltage.
15. To verify inverse square law of radiations using a photo-electric cell.
16. To measure wavelength of a He-Ne/diode laser using a diffraction grating.
17. To measure numerical aperture (NA) of an optical fiber.
18. Study of an optical projection system (OHP/LCD) - project report.

Suggested Student Activities & Strategies :-

Apart from classroom and laboratory learning following are the suggested student related activities which can be undertaken to accelerate the attainment of various outcomes of the course.

a. Make survey of different physical products and compare the following points

- Measurements of dimensions
- Properties
- Applications

b. Library survey regarding engineering materials/products used in different industries

c. Seminar on any relevant topic.

Teachers should use the following strategies to achieve the various outcomes of the course.

- Different methods of teaching and media to be used to attain classroom attention.
- Massive open online courses (MOOCs) may be used to teach various topics/sub topics.
- 15-20% of the topics which are relatively simpler or descriptive in nature should be given to the students for self-learning and assess the development of competency through classroom presentations/projects.
- Micro-projects on relevant may be given to group of students for hand-on experiences.

Learning Outcome:

After undergoing this subject, the student will be able to;

a) Apply concept of vibrations and determine the time period of vibrating objects.

b) ***Use of equipment for determining velocity of ultrasonics in different liquids.***

c) Verify optical laws; reflection, refraction from plane interfaces and surfaces.

d) Apply knowledge of optics to determine focal length and magnifying power of optical lenses.

e) Understand uses of electrical components and meters and verify Ohm's law for flow of current.

f) Quantify resistances and verify laws of series and parallel combination of resistances.

g) Apply concept of electrical vibrations in determine frequency of AC main.

h) Analyse electrical circuits and verify Kirchhoff's law governing electrical circuits.

i) Measure resistance of a galvanometer and how it is converted into an ammeter and voltmeter.

j) Investigate characteristics of semiconductor diodes, photoelectric cells and determine operational parameters associated with their performance.

k) Work with laboratory lasers and understand method to measure the wavelength of the light emitted from a laser.

l) Handle optical fibers and determine numerical aperture of given optical fiber.

m) Understand construction and working of an optical projection system.

Recommended Books:

1. Text Book of Physics for Class XI& XII (Part-I, Part-II); N.C.E.R.T., Delhi
2. Comprehensive Practical Physics, Vol, I & II, JN Jaiswal, Laxmi Publications (P) Ltd., New Delhi
3. Practical Physics by C. L. Arora, S. Chand & Company Ltd.
4. e-books/e-tools/ learning physics software/you Tube videos/ websites etc.

INTRODUCTION TO IT SYSTEMS LAB

Subject Code	Practical			No of Periods in One Session : 60			Credits
	No. of Periods Per Week			Full Marks	:	50	02
2002207	L	T	P/S	Internal(PA)	:	15	
	-	-	04	External(ESE)	:	35	
	-	-	-	-	:	-	

Course Objectives: -

This Lab course is intended to practice whatever is taught in theory class of 'Introduction of IT Systems' and become proficient in using computing environment - basic computer skills, basic application software tools, Computer Hardware, cyber security features, etc.

Course Content: -

S.No.	Topics for Practice
1	Browser features, browsing, using various search engines, writing search queries
2	Visit various e-governance/Digital India portals, understand their features, services offered
3	Read Wikipedia pages on computer hardware components, look at those components in lab, identify them, recognize various ports/interfaces and related cables, etc.
4	Install Linux and Windows operating system on identified lab machines, explore various options, do it multiple times
5	Connect various peripherals (printer, scanner, etc.) to computer, explore various features of peripheral and their device driver software.
6	Practice HTML commands, try them with various values, make your own Webpage
7	Explore features of Open Office tools, create documents using these features, do it multiple times
8	Explore security features of Operating Systems and Tools, try using them and see what happens.

This is a skill course. More you practice, better it will be.

References:

1. Online resources, Linux man pages, Wikipedia.
2. R.S. Salaria, Computer Fundamentals, Khanna Publishing House.
3. Ramesh Bangia, PC Software Made Easy – The PC Course Kit, Khanna Publishing House.
4. Mastering Linux Shell Scripting: A practical guide to Linux command-line, Bash scripting, and Shell programming, by Mokhtar Ebrahim, Andrew Mallett.
5. IT Essentials PC Hardware and Software Companion Guide, Davis Anfinson and Ken Quamme, CISC Press, Pearson Education.
6. PC Hardware and A+ Handbook, Kate J. Chase PHI (Microsoft).

Course outcomes:-

At the end of the course student will be able to comfortably work on computer, install and configure OS, assemble a PC and connect it to external devices, write documents, create worksheets, prepare presentations, protect information and computers from basic abuses/attacks.

FUNDAMENTALS OF ELECTRICAL AND ELECTRONICS ENGINEERING LAB

Subject Code	Practical			No of Periods in One Session : 60			Credits
	No. of Periods Per Week			Full Marks	:	50	
2002208	L	T	P/S	Internal(PA)	:	15	01
	-	-	04	External(ESE)	:	35	
	-	-	-	-	:	-	

Suggested Practicals/Exercises:

The practical in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Approx. Hrs.
1.	Determine the permeability of magnetic material by plotting its B-H curve.	05
2.	Measure voltage, current and power in 1-phase circuit with resistive load.	05
3.	Measure voltage, current and power in R-L series circuit.	05
4.	Determine the transformation ratio (K) of 1-phase transformer.	05
5.	Connect single phase transformer and measure input and output quantities.	05
6.	Make Star and Delta connection in induction motor starters and measure the line and phase values.	05
7.	Identify various passive electronic components in the given circuit	05
8.	Connect resistors in series and parallel combination on bread board and measure its value using digital multimeter.	05
9.	Connect capacitors in series and parallel combination on bread board and measure its value using multimeter.	05
10.	Use multimeter to measure the value of given resistor.	05
11.	Determine the value of given resistor using digital multimeter to confirm with colour code.	05
12.	Test the PN-junction diodes using digital multimeter.	05
	Total	**60**

References:

1. Ritu Sahdev, Basic Electrical Engineering, Khanna Publishing House, 2018
2. Mittle and Mittal, Basic Electrical Engineering, McGraw Education, New Delhi, 2015, ISBN : 978-0-07-0088572-5
3. Saxena, S. B. Lal, Fundamentals of Electrical Engineering, Cambridge University Press, latest edition ISBN : 9781107464353
4. Theraja, B. L., Electrical Technology Vol – I, S. Chand publications, New Delhi, 2015, ISBN: 9788121924405

5. Theraja, B. L., Electrical Technology Vol – II, S. Chand publications, New Delhi, 2015, ISBN: 9788121924375

6. Jegathesan, V., Basic Electrical and Electronics Engineering, Wiley India, New Delhi, 2015, ISBN : 97881236529513

7. Sedha, R.S., A text book of Applied Electronics, S.Chand ,New Delhi, 2008, ISBN-13: 978-8121927833

8. Malvino, Albert Paul, David, Electronics Principles, McGraw Hill Eduction, New Delhi,2015, ISBN-13**:** 0070634244-978

9. Mehta, V.K., Mehta, Rohit, Principles of Electronics, S. Chand and Company, New Delhi, 2014, ISBN-13-9788121924504

10. Bell Devid, Fundamental of Electronic Devices and Circuits, Oxford University Press, New Delhi 2015 ISBN : 9780195425239

Suggested Softwares/Learning Websites:

a. en.wikipedia.org/wiki/Transformer
b. www.animations.physics.unsw.edu.au//jw/AC.html
c. www.alpharubicon.com/altenergy/understandingAC.htm
d. www.electronics-tutorials
e. learn.sparkfun.com/tutorials/transistors
f. www.pitt.edu/~qiw4/Academic/ME2082/Transistor%20Basics.pdf
g. www.technologystudent.com/elec1/transis1.htm
h. www.learningaboutelectronics.com
i. www.electrical4u.com

Course Outcomes:

At the end of the course student will be able to:

1. Understand basic principle and operation of electric circuits and machines.
2. Solve basic problems related to electrical circuits and machines. Explain the operation of different electrical technologies.
3. Demonstrate an understanding of the control systems.
4. Understand the basic circuit elements
5. Understand different types of signal waveforms.
6. Understand logic gates and apply them in various electronic circuits.
7. Understand the basic concepts of op-amps, and their applications.
8. Use relevant electric/electronic protective devices safely.

ENGINEERING MECHANICS LAB.

<table>
<tr><td rowspan="5">Subject Code
2002209</td><td colspan="3">Practical</td><td colspan="3">No of Periods in One Session : 45</td><td>Credits</td></tr>
<tr><td colspan="3">No. of Periods Per Week</td><td>Full Marks</td><td>:</td><td>50</td><td rowspan="4">02</td></tr>
<tr><td>L</td><td>T</td><td>P/S</td><td>Internal(PA)</td><td>:</td><td>15</td></tr>
<tr><td>-</td><td>-</td><td>03</td><td>External(ESE)</td><td>:</td><td>35</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>-</td><td>:</td><td>-</td></tr>
</table>

Course Objectives:

Following are the objectives of this course:

1) To obtain resultant of various forces
2) To calculate support reactions through conditions of equilibrium for various structures
3) To understand role of friction in equilibrium problems
4) To know fundamental laws of machines and their applications to various engineering problems

List of Practical to be performed (Perform any 10 Practicals) :

1. Determine resultant of concurrent force system applying Law of Polygon of forces using force table.
2. Verify Lami's theorem.
3. Study forces in various members of Jib crane.
4. Determine support reactions for simply supported beam.
5. Determine coefficient of friction for motion on horizontal and inclined plane.
6. Determine centroid of geometrical plane figures.
7. To find the M.A., V.R., Efficiency and law of machine for Simple Screw Jack.
8. To find the M.A., V.R., Efficiency and law of machine for Differential Axle and Wheel.
9. Derive Law of machine using Worm and worm wheel.
10. Derive Law of machine using Single purchase crab.
11. Derive Law of machine using double purchase crab.
12. Derive Law of machine using Weston's differential or wormed geared pulley block.

Suggested Learning Resources:

1. Bedi D.S., Engineering Mechanics, Khanna Publishing House
2. Khurmi, R.S., Applied Mechanics, S.Chand & Co. New Delhi.
3. Bansal R K, A text book of Engineering Mechanics, Laxmi Publications.
4. Ramamrutham, Engineering Mechanics, S.,S Chand & Co. New Delhi.
5. Dhade, Jamadar & Walawelkar, Fundamental of Applied Mechanics, Pune Vidhyarthi Gruh.
6. Ram, H. D.; Chauhan, A. K. Foundations and Applications of Applied Mechanics, Cambridge Uni- versity Press.
7. Meriam, J. L., Kraige, L.G. , Engineering Mechanics- Statics, Vol. I, Wiley Publication, New Delhi.

Course outcomes:

After completing this course, student will be able to

1. Identify the force systems for given conditions by applying the basics of mechanics.
2. Determine unknown force(s) of different engineering systems.
3. Apply the principles of friction in various conditions for useful purposes.
4. Find the centroid and centre of gravity of various components in engineering systems.
5. Select the relevant simple lifting machine(s) for given purposes.

COURSE UNDER MOOCS / SWAYAM / ETC / OTHERS

Subject Code 2002210	Term Work			No of Periods in One Session :			Credits
	No. of Periods Per Week			Full Marks	:	20	02
	L	T	P/S	Internal(PA)	:	06	
	-	-	-	External(ESE)	:	14	
	-	-	-	-	:	-	

KYP / IT ESSENTIAL / PYTHON / OTHERS

Subject Code	Term Work			No of Periods in One Session :			Credits
	No. of Periods Per Week			Full Marks	:	20	01
Subject Code 2002211	L	T	P/S	Internal	:	06	
	-	-	-	External Comm.	:	14	
	-	-	-	-	:	-	

ENVIRONMENTAL SCIENCE

<table>
<tr><td rowspan="5">Subject Code
2002212</td><td colspan="3">Term Work</td><td colspan="3">No of Periods in One Session : 30</td><td>Credits</td></tr>
<tr><td colspan="3">No. of Periods Per Week</td><td>Full Marks</td><td>:</td><td>10</td><td rowspan="4">-</td></tr>
<tr><td>L</td><td>T</td><td>P/S</td><td>Internal(PA)</td><td>:</td><td>10</td></tr>
<tr><td>-</td><td>-</td><td>02</td><td></td><td>:</td><td>-</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>-</td><td>:</td><td>-</td></tr>
</table>

Course Objectives:

Technicians working in industries or elsewhere essentially require the knowledge of environmental science so as to enable them to work and produce most efficient, economical and eco-friendly finished products.

- Solve various engineering problems applying ecosystem to produce eco – friendly products.
- Use relevant air and noise control method to solve domestic and industrial problems.
- Use relevant water and soil control method to solve domestic and industrial problems.
- To recognize relevant energy sources required for domestic and industrial applications.

Course Content:

Pre requisite: - High School Chemistry

ENVIRONMENTAL SCIENCE

UNIT-1 Environmental Studies :

Definition of Environment, Components of Environment, Biotic and Abiotic Components, Layers **[06]** of Atmosphere, Greenhouse Effect and Global Warming, Ozone Layer-Earth's Protective Umbrella, Depletion of Ozone Layer. Consequences of Ozone Depletion.

UNIT– 2 Water Pollution and Soil Pollution

Introduction, Sources of Water Pollution, Effects of Water Pollution, Control of Water **[07]**

Pollution, Oxygen Demanding Waste, Determination of Dissolved Oxygen, Turbidity, pH, Biological Oxygen Demand, Chemical Oxygen Demand. Soil Pollution: Introduction, Composition of the Soil, Types of Soil, Causes, Effects and control of Soil Pollution.

UNIT- 3 Air Pollution and Noise Pollution :

Introduction, Composition of Air, Causes and effects of Air Pollution, Primary and **[07]** Secondary Pollutants, Control of Air Pollution, Acid Rain, Harmful effects of Acid Rain. Smog and its kind, Difference between Classical smog and Photochemical Smog. Causes and effects of Noise Pollution.

UNIT– 4 Radioactive Pollution : **[06]**

Introduction, Kind of Radiation, Law of Radioactivity Decay, Mass Defect and Binding Energy, Nuclear Fission and Fusion, Harmful effects of Radiation.

UNIT-5 Renewable Sources of Energy : **[04]**

Introduction of Solar Energy, Wind Energy, Tidal Energy, Biogas.

References:

(a) Suggested Learning Resources:

Books:

1 S.C. Sharma & M.P. Poonia, Environmental Studies, Khanna Publishing House, New Delhi

2. C.N. R. Rao, Understanding Chemistry, Universities Press (India) Pvt. Ltd., 2011.

3. Arceivala, Soli Asolekar, Shyam, Waste Water Treatment for Pollution Control and

4. Reuse, Mc-Graw Hill Education India Pvt. Ltd., New York, 2007, ISBN:978-07-062099-

5. Nazaroff, William, Cohen, Lisa, Environmental Engineering Science, Willy, New York, 2000, ISBN 10: 0471144940.

6. O.P. Gupta, Elements of Environmental Pollution Control, Khanna Publishing House, New Delhi

7. Rao, C. S., Environmental Pollution Control and Engineering, New Age International Publication, 2007, ISBN: 81-224-1835-X.

8. Rao, M. N.Rao, H.V.N, Air Pollution, Tata Mc-Graw Hill Publication, New delhi, 1988, ISBN: 0-07- 451871-8.

9. Frank Kreith, Jan F Kreider, Principles of Solar Engineering, McGraw-Hill, New York ; 1978, ISBN: 9780070354760.

10. Aldo Vieira, Da Rosa, Fundamentals of renewable energy processes, Academic Press Oxford, UK; 2013. ISBN: 9780123978257.

11. Patvardhan, A.D, Industrial Solid Waste, Teri Press, New Delhi, 2013, ISBN:978-81-7993-502-6

12. Metcalf & Eddy, Waste Water Engineering, Mc-Graw Hill, New York, 2013, ISBN: 077441206.

Keshav Kant, Air Pollution & Control, Khanna Publishing House, New Delhi (Edition 2018)

(a) Open source software and website address :

1) www.eco-prayer.org
2) www.teriin.org
3) www.cpcp.nic.in
4) www.cpcp.gov.in
5) www.indiaenvironmentportal.org.in
6) www.whatis.techtarget.com
7) www.sustainabledevelopment.un.org
8) www.conserve-energy-future.com)

Teachers should use the following strategies to achieve the various outcomes of the course.

- Different methods of teaching and media to be used to attain classroom attention.
- Massive open online courses (MOOCs) may be used to teach various topics/sub topics.
- 15-20% of the topics which are relatively simpler of descriptive in nature should be given to the students for self-learning and assess the development of competency through classroom presentations.

- Micro-projects may be given to group of students for hand-on experiences
- Encouraging students to visit to sites such as Railway station and research establishment around the institution.

Course outcomes

At the end of the course student will be able to

1. Understand the ecosystem and terminology and solve various engineering problems applying ecosystem knowledge to produce eco – friendly products.
2. Understand the suitable air, extent of noise pollution, and control measures and acts.
3. Understand the water and soil pollution, and control measures and acts.
4. Understand different renewable energy resources and efficient process of harvesting.

STATE BOARD OF TECHNICAL EDUCATION, BIHAR

Scheme of Teaching and Examinations for

IIIrd SEMESTER DIPLOMA IN ELECTRICAL ENGINEERING/ ELECTRICAL & ELECTRONICS ENGINEERING.

(Effective from Session 2020- 21 Batch)

THEORY

Sr. No.	SUBJECT	SUBJECT CODE	TEACHING SCHEME	EXAMINATION-SCHEME							
			Periods per Week	Hours of Exam.	Teacher's Assessment (TA) Marks A	Class Test (CT) Marks B	End Semester Exam. (ESE) Marks C	Total Marks (A+B+C)	Pass Marks ESE	Pass Marks in the Subject	Credits
1.	Introduction to Electric Power Generation Systems	2020301	03	03	10	20	70	100	28	40	03
2.	Electrical Circuits	2020302	03	03	10	20	70	100	28	40	03
3.	Electrical and Electronic Measurements	2020303	04	03	10	20	70	100	28	40	04
4.	Electric Motors and Transformers	2020304	04	03	10	20	70	100	28	40	04
5.	Fundamentals of Basic electronics &Digital Electronics	2020305	03	03	10	20	70	100	28	40	03
		Total: -	**17**				**350**	**500**			17

PRACTICAL

Sr. No.	SUBJECT	SUBJECT CODE	TEACHING SCHEME	EXAMINATION-SCHEME					
			Periods per Week	Hours of Exam.	Practical		Total Marks	Pass Marks in the Subject	Credits
					Internal (PA)	External (ESE)			
6.	Introduction to electric power generation laboratory	2020306	02 50% physical 50% Virtual	03	15	35	50	20	01
7.	Electrical Circuits Laboratory	2020307	02 50% physical 50% Virtual	03	15	35	50	20	01
8.	Web Technology Lab	2018308	02 50% physical 50% Virtual	03	07	18	25	10	01
9.	Electrical and Electronic Measurements Laboratory	2020309	02 50% physical 50% Virtual	03	07	18	25	10	01
10.	Electric Motors and Transformers Laboratory	2020310	02 50%physical 50% Virtual	03	15	35	50	20	01
		Total: -	**10**				**200**		05

TERM WORK

Sr. No.	SUBJECT	SUBJECT CODE	TEACHING SCHEME	EXAMINATION-SCHEME				
			Periods per Week	Marks of Internal (PA)	Marks of External (ESE)	Total Marks	Pass Marks in the Subject	Credits
11.	Python	2018311	02	07	18	25	10	01
12.	Fundamentals of Basic electronics &Digital Electronics	2020312	04	07	18	25	10	01
		Total: -	**06**			**50**		**02**

Total Periods per week Each of duration One Hour **33**	Total Marks = **750**	**24**

INTRODUCTION TO ELECTRIC POWER GENERATION SYSTEMS
(ELECTRICAL ENGINEERING GROUP)

Subject Code	Theory						Credits
2020301	No. of Periods Per Week			Full Marks	:	100	03
	L	T	P/S	ESE	:	70	
	03	00	—	TA	:	10	
	—	—	—	CT	:	20	

Course Objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- An understanding of basic abstractions of electrical power generations from conventional and nonconventional sources of energy.
- The capability to use abstractions to comprehend and analyze the impact of various system on environments and economics aspects of energy generation.
- Maintain the efficient operation of various electric power generating plants.
- The capability to incorporate the knowledge of electrical power generation in other field of science, engineering and economics.

CONTENTS: THEORY

	Name of the Topic	Hrs./Unit
Unit -I	**Thermal Power Plants: Coal, Gas/ Diesel and Nuclear-based** Lay out and working of a typical thermal power plant with steam turbines and electric generators. Properties of conventional fuels used in the energy conversion equipment used in thermal powerplants: Coal, Gas/diesel. Nuclear fuels–fusion and fission action safe practices and working of various thermal power plants: coal-based, gas-based, diesel-based, and nuclear-based. Functions of the following types of thermal power plants and their major auxiliaries: Coal fired boilers: fire tube and water tube. Gas / diesel base combustion engines Types of nuclear reactors: Disposal of nuclear waste and nuclear shielding. Thermal power plants in Bihar.	10
Unit -II	**Large and Micro-Hydro Power Plants** Energy conversion process of hydro power plant. Classification of hydro power plant: High, medium and low head. Construction and working of hydro turbines used in different types of hydro power plant: . High head – Pelton turbine, medium head – Francis turbine, Low head – Kaplan turbine. Safe Practices for hydro power plants. Different types of micro-hydro turbines for different heads Pelton Francis and Kaplan turbines Locations of these different types of large and micro-hydro power plants in Bihar Potential locations of micro-hydro power plants in Bihar	8
Unit - III	**Solar and Biomass based Power Plants** Solar Map of India: Global solar power radiation. Solar Power Technology a. Concentrated Solar Power (CSP) plants, construction and working of Power Tower, Parabolic Trough, Parabolic Dish, Fresnel Reflectors b. Solar Photovoltaic (PV) power plant: layout, construction, working. C. Biomass-based Power Plants. Layout of a Bio-chemical based (e.g. biogas) power plant: a. Layout of a Thermo-chemical based (e.g. Municipal waste) power plant b. Layout of an Agrochemical based (e.g. bio-diesel) power plant Features of the solid, liquid and gas biomasses as fuel for biomass power plant.	10

Unit - IV	**Wind Power Plants** Wind Map of India**:** Wind power density in watts per square meter, Lift and drag principle; long path theory. Layout of Horizontal axis large wind power plant: Geared wind power plant. Direct-drive wind power plant. Salient Features of electric generators used in large wind power plants: Constant Speed Electric Generators: Squirrel Cage Induction Generators (SCIG), Wound Rotor Induction Generator (WRIG) Variable Speed Electric Generators: Doubly-fed induction generator (DFIG)wound rotor synchronous generator (WRSG), permanent magnet synchronous generator (PMSG)	8
Unit - V	**Small Wind Turbines** Horizontal axis small wind turbine: direct drive type, components and working Horizontal axis small wind turbine: geared type, components and working Vertical axis small wind turbine: direct drive and geared, components and working Type of towers and installation of small wind turbines on roof tops and open fields. Electric generators used in small wind power plants	4
Unit - VI	**Economics of Power Generation and Interconnected Power System** Related terms: connected load, firm power, cold reserve, hot reserve, spinning reserve. Base load and peak load plants; Load curve, load duration curve, integrated duration curve, Cost of generation: Average demand, maximum demand, demand factor, plant capacity factor, plant use factor, diversity factor, load factor and plant load factor. Choice of size and number of generator units, combined operation of power station. Causes and Impact and reasons of Grid system fault: State grid, national grid, brownout and black out; sample blackouts at national and international level	8
	Total	48

References:

1. Power Plant Engineering, by P K Nag. McGraw Hill, New Delhi, ISBN:978-9339204044
2. Electrical Power Generation, by Tanmoy Deb, Khanna Publishing House Delhi (Ed.2018)
3. Generation of Electrical Energy by B.R. Gupta, Chand &Co New Delhi,
4. Electrical Power generation by Dr. S. L. Uppal Khanna Publishers.
5. Solar Photovoltaics Fundamentals Technologies and Applications by Solanki, Chetan Singh PHI learning, New Delhi ISBN:9788120351110
6. Wind Power Plants and Project Development by T Wizelius Earnest Joshua–PHI
7. A Course in Electrical Power by JB Gupta S K Katarina and Sons, New Delhi.2014,
8. A Course in Electrical Power by Sony Gupta Bhatnagar Dhanpat Rai and Sons
9. Electrical Power Generation — Kamal Singh — FPH
10. Electrical Power Generation — Ashirwad Kumar — FPH
11. Introduction to Electric Generation Systems — Deepak Garg — FPH

Course Outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and so that the student demonstrates the following industry-oriented Cos associated with the above-mentioned competency:

a) Maintain the optimized working of the thermal power plant.
b) Maintain the optimized working of large and micro hydro power plants.
c) Maintain the optimized working of solar and biomass-based power plants.
d) Maintain the optimized working of wind power plants.
e) Select the adequate mix of power generation based on economic operation.

*****

ELECTRICAL CIRCUITS
(ELECTRICAL ENGINEERING GROUP)

<table>
<tr><td rowspan="5">Subject Code
2020302</td><td colspan="3">Theory</td><td colspan="3"></td><td>Credits</td></tr>
<tr><td colspan="3">No. of Periods Per Week</td><td>Full Marks</td><td>:</td><td>100</td><td rowspan="4">03</td></tr>
<tr><td>L</td><td>T</td><td>P/S</td><td>ESE</td><td>:</td><td>70</td></tr>
<tr><td>03</td><td>—</td><td>—</td><td>TA</td><td>:</td><td>10</td></tr>
<tr><td>—</td><td>—</td><td>—</td><td>CT</td><td>:</td><td>20</td></tr>
</table>

Course Objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Impart a basic knowledge of electrical quantities such as current, voltage, power, energy and frequency to understand the impact of technology in a global and societal context.
- Provide working knowledge for the analysis of basic DC and AC circuits used in electrical and electronic devices.
- Maintain electrical systems applying AC and DC circuit fundamentals

CONTENTS: THEORY

	Name of the Topic	Hrs./Unit
Unit -I	**Single Phase A.C Series Circuits** Generation of alternating voltage, Phasor representation of sinusoidal quantities R, L, C circuit elements its voltage and current response R-L, R-C, R-L-C combination of A.C series circuit, impedance, reactance, impedance triangle, Power factor, active power, reactive power, apparent power, power triangle and vector diagram Resonance, Bandwidth, Quality factor and voltage magnification in series R-L, R-C, R-L-C circuit	10
Unit -II	**Single Phase A.C Parallel Circuits** R-L, R-C and R-L-C parallel combination of A.C. circuits. Impedance reactance phasor diagram, impedance triangle R-L, R-C, R-L-C parallel A.C. circuits power factor active power apparent power reactive power, power triangle Resonance in parallel R-L, R-C, R-L-C circuit, Bandwidth, Quality factor and voltage magnification	10
Unit -III	**Three Phase Circuits** Phasor and complex representation of three phase supply Phase sequence and polarity Types of three-phase connections, Phase and line quantities in three phase star and delta system Balanced and unbalanced load, neutral shift in unbalanced load Three phase power, active, reactive and apparent power in star and delta system.	10
Unit - IV	**Network Reduction and Principles of Circuit Analysis** Source transformation Star/delta and delta/star transformation, Mesh Analysis Node Analysis	08

Unit - V	**Network Theorems** Superposition theorem. Thevenin's theorem. Norton's theorem Maximum power transfer theorem, Reciprocity theorem Tellegen's Theorem Duality in electric circuits	10
	Total	48

References:

1. Networks & Systems, by Ashfaq Husain, Khanna Book Publishing, New Delhi.
2. Fundamentals of Electrical Network by B. R Gupta Singhal Vandana S. Chand and Co. New Delhi ISBN:978-81-219-2318- 7
3. Fundamentals of Electrical Engineering by Saxena, S.B Lal, K .Dasgupta
4. A Text Book of Electrical Technology Vol-I by A K Theraja, B.L:Theraja; S.Chand & Co Ram Nagar New Delhi ISBN: 9788121924405
5. Circuit and network by A. Sudhakar A.S. Shyamalan, S. Palli;, McGraw Hill Education, New Delhi,ISBN:978-93-3921- 960-4
6. Electric Circuits by Bell, David A. Oxford University Press New Delhi, ISBN:978-01-954-2524-6
7. Introductory circuit Analysis by R.L Boylested, Wheeler, New Delhi, ISBN:978-00-231-3161-5
8. Basic Electrical Engineering by V.N. Mittel Arvind Mittel, McGraw Hill Education, Noida, ISBN:978-00-705-9357-2
9. Electric Circuit Analysis, by A.K. CHAKRAVARTI Dhan pat rai publication.
10. Circuit theory by S Saliva Hanan, S. Pravin Kumar, Vikas Publishing House Pvt. Ltd, Noida; ISBN:978-93259- 7418-0
11. Electrical Circuits & Network Umesh Kumar FPH
12. Electrical Circuits O.P.Sharma FPH

Course Outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry-oriented Cos associated with the above-mentioned competency:

a) Trouble shoot problems related to single phase A.C series circuits.
b) Trouble shoot problems related to single phase A.C parallel circuits.
c) Trouble shoot problems related to three phase circuits.
d) Use principles of circuit analysis to trouble shoot electric circuits.
e) Apply network theorems to troubleshoot electric circuits.

*****

ELECTRICAL AND ELECTRONIC MEASUREMENTS
(ELECTRICAL ENGINEERING GROUP)

Subject Code	Theory						Credits
2020303	No. of Periods Per Week			Full Marks	:	100	04
	L	T	P/S	ESE	:	70	
	04	—	—	TA	:	10	
	—	—	—	CT	:	20	

Course Objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

Identify the various parameters that are measurable in electronic instrumentation.

- Employ appropriate instruments to measure given sets of parameters.
- Practice the construction of testing and measuring set up for electronic systems.
- To have a deep understanding about instrumentation concepts which can be applied to Control systems.
- Use relevant measuring instrument in different electrical applications.

CONTENTS: THEORY

Chapter	Name of the Topic	Hrs./Unit
Unit -I	**Fundamentals of Measurements** Measurement: Significance, units, fundamental quantities and standards Classification of Instrument Systems: Null and deflection type instruments Absolute and secondary instruments Analog and digital instruments Static and dynamic characteristics, types of errors Calibration: need and procedure Classification of measuring instruments: indicating, recording and integrating instruments. Essential requirements of an indicating instruments	08
Unit – II	**Measurement of voltage and current** DC Ammeter: Basic, Multi range, Universal shunt, DC Voltmeter: Basic, Multi-range, concept of loading effect and sensitivity. AC voltmeter: Rectifier type (half wave and full wave) CT and PT: construction, working and applications. Clamp-on meter.	10
Unit -III	**Measurement of Electric Power** Analog meters: Permanent magnet moving coil (PMMC) and Permanent magnet moving iron (PMMI) meter, their construction, working, salient features, merits and demerits Dynamometer type wattmeter: Construction and working Range: Multiplying factor and extension of range using CT and PT Errors and compensations. Active and reactive power measurement: One, two and three wattmeter method. Effect of Power factor on wattmeter reading in two wattmeter method. Maximum Demand indicator	16

Unit -IV	**Measurement of Electric Energy** Single and three phase electronic energy meter: Constructional features and working principle. Errors and their compensations. Calibration of single-phase electronic energy meter using direct loading.	04
Unit -V	**Circuit Parameter Measurement, CRO and Other Meters** Measurement of resistance: Low resistance: Kelvin's double bridge, Medium Resistance: Voltmeter and ammeter method	08
Unit -VI	High resistance: Megger and Ohm meter: Series and shunt Measurement of inductance using Anderson bridge (no derivation and phasor diagram) Measurement of capacitance using Schering bridge (no derivation and phasor diagram) Single beam/single trace CRO, Digital storage Oscilloscope**:** Basic block diagram, working, Cathode ray tube, electrostatic deflection, vertical amplifier, time base generator, horizontal amplifier, measurement of voltage/ amplitude/ time period/ frequency/ phase angle delay line, specifications. Other meters: Earth tester, Digital Multimeter; L-C-R meter, Frequency meter (ferromagnetic and Weston type), Phase sequence indicator, power factor meter (single phase and three phase dynamometer type), Synchroscope, Tri-vector meter. Signal generator: need, working and basic block diagram. Function generator: need, working and basic block diagram, function of symmetry.	18
	Total	64

References:

1. A Text Book of Electrical Technology Vol-I (Basic Electrical Engg.) by A.K., Theraja B. L,Theraja S.Chand and Co. New Delhi, ISBN:9788121924405
2. Basic Electrical Engineering Mittle by V.N. McGraw-Hill New Delhi, ISBN:978-0-07-0088572-5,
3. Edward Hughes, Electrical Technology, Pearson Education, New Delhi, ISBN-13: 978-0582405196
4. Electrical and Electronic Measurement and Instrumentation, R. KRajput, S.Chand and Co. New Delhi, ISBN :9789385676017
5. Electrical and Electronics Measurement sand Instrumentation. By A.K. Sawhney Dhanpat Rai and Sons, New Delhi, ISBN :9780000279744
6. Electrical Measurements and Measuring Instruments by N.V. Suryanarayana S. Chand and Co. New Delhi, ISBN:8121920116

7.	Electrical Measurements	S.N. Bhargava	FPH
8.	Electrical Measurements	Aashirvad Kumar	FPH
9.	Electrical and Electronic Measurements	Deepak Kumar	FPH

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry-oriented Cos associated with the above-mentioned competency:

a) Check the working of the electrical measuring instrument.
b) Use different types of measuring instruments for measuring voltage and current.
c) Use different types of measuring instruments for measuring electric power
d) Use different types of measuring instruments for measuring electric energy.
e) Use different types of electrical instruments for measuring various ranges of electrical parameters.

ELECTRIC MOTORS AND TRANSFORMERS
(ELECTRICAL ENGINEERING GROUP) -

Subject Code	Theory						Credits
Subject Code 2020304	No. of Periods Per Week			Full Marks	:	100	04
	L	T	P/S	ESE	:	70	
	04	—	—	TA	:	10	
	—	—	—	CT	:	20	

Course Objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Provide the basic concept of DC machines and Transformers.
- Develop the skills of the students in the areas of machines and transformers by identifying the current problem in the industries and bring solutions through research.
- Diagnose the condition of DC machines and Transformers.
- Maintain electric motors and transformers.

CONTENTS: THEORY

Chapter	Name of the topic	Hrs./Unit
Unit -I	**DC Generators** DC generator: construction, parts, materials and their functions. Principle of operation of DC generator: Fleming's right hand rule, schematic diagrams, E.M.F. equation of generator, armature reaction, commutation. Applications of DC generators. Classification of measuring instruments: indicating, recording and integrating instruments.	12
Unit - II	**D.C. Motors** DC motor: Types of DC motors. Fleming's left-hand rule, Principle of operation of, Back E.M.F and its significance, Voltage equation of DC motor. Torque and Speed; Armature torque, Shaft torque, BHP, Brake test, losses, efficiency. DC motor starters: Necessity, two point and three-point starters. Speed control of DC shunt and series motor: Flux and Armature control. Brushless DC Motor: Construction and working.	14
Unit -III	**Single Phase Transformers** Types of transformers: Shell type and core type; Construction: Parts and functions, materials used for different parts: CRGO, CRNGO, HRGO, amorphous cores, Transformer: Principle of operation, EMF equation of transformer: Derivation, Voltage transformation ratio, Significance of transformer ratings Transformer No-load and on-load phasor diagram, Leakage reactance, Equivalent circuit of transformer: Equivalent resistance and reactance. Voltage regulation and Efficiency: Direct loading OC/SC method, All day efficiency.	14
Unit -IV	**Three Phase Transformers** Bank of three single phase transformers, Single unit of three phase transformer Distribution and Power transformers. Construction, cooling, three phase transformers connections as per IS:2026 (part IV)-1977, Three phase to two phase conversion (Scott Connection), Selection of transformer as per IS: 10028 (Part I)-1985, Criteria for selection of distribution transformer, and power transformer, Amorphous Core type Distribution Transformer, Specifications of three- phase distribution transformers as per IS:1180 (part I)-1989 Need of parallel operation of three phase transformer, Conditions for parallel operation. Polarity tests on mutually inductive coils and single-phase transformers; Polarity test, Phasing out test on Three-phase transformer	16

Unit -V	**Special Purpose Transformers** Single phase and three phase auto transformers: Construction, working and applications. Instrument Transformers: Construction, working and applications of Current transformer and Potential transformer. Isolation transformer: Constructional Features and applications. Single phase welding transformer: constructional features and applications. Pulse transformer: constructional features and applications. 'K' factor of transformers: overheating due to non-linear loads and harmonics.	08
	Total	64

References:

1. Electrical Machines, Vol- I,II by G.C. Garg & P.S. Bimbhra, Khanna Book Publishing House(ISBN:978- 9386173-447, 978-93-86173-607), New Delhi
2. Mittle,V.N.andMittle,Arvind.,BasicElectricalEngineering,McGrawHillEducation,New Delhi,ISBN: 9780070593572
3. Electrical Machines by D.P Kothari .and Nagrath, I.J.McGraw Hill Education. New Delhi, ISBN: 9780070699670
4. Electrical Machines by J.B. Gupta McGraw Hill Education, New Delhi,ISBN:9789332902855
5. Principle so Electrical Machines by Rohit Mehta, and V.K.Mehta,S.ChandandCo.Ltd.,NewDelhi,ISBN: 9788121930888
6. Electrical Technology Vol-II (A C and DC machines) by B.L. Theraja, S.Chand and Co. Ltd., New Delhi, ISBN: 9788121924375
7. Electrical Machines Theory and Practice, M.N. Bandyopadhyay, PHI Learning Pvt.Ltd.,New Delhi, ISBN: 9788120329973Vi
8. DC Machines and Transformers by K.Murugesh Kumar,ISBN:9788125916055
9. Electric Motors and Transformers Deepak Kumar FPH

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry-oriented Co associated with the above-mentioned competency:

a) Maintain different types of DC generators

b) Maintain different types of DC motors.

c) Maintain single phase transformer.

d) Maintain three phase transformers.

e) Maintain different types of special purpose transformers used in different applications.

****

Fundamental of Basic Electronics & Digital Electronics
(ELECTRICAL ENGINEERING GROUP)

Subject Code	Theory						Credits
2020305	No. of Periods Per Week			Full Marks	:	100	03
	L	T	P/S	ESE	:	70	
	03	00	—	TA	:	10	
	—	—	—	CT	:	20	

Course Learning Objectives:

- To acquire the basic knowledge of digital logic levels and application of knowledge to understand digital electronics circuits.
- To prepare students to perform the analysis and design of various digital electronic circuits.

CONTENTS: THEORY

	Name of the topic	Hrs./Unit
Unit -I	**Boolean Algebra & Logic Gates** Introduction to different Number systems: Binary, Octal, Decimal & Hexadecimal & their Conversion from one another Rules and Laws of Boolean Algebra – DE Morgan's Law Logic Gates: AND, OR, NOT, NAND, NOR, XOR, XNOR, Symbolic representation & Truth Table Karnaugh Maps (K-Maps) & its use for simplification of simple Boolean expressions	8
Unit -II	**Combinational Logic Circuit** Arithmetic Circuits: Addition, Subtraction, 1's Compliment, 2's compliment, Half Adder, Full Adder, Half subtractor, full subtractor Encoder, Decoder Multiplexer, Demultiplexer	6
Unit - III	**Sequential Logic Circuit & Data Converter** Flip Flops: SR, JK, T & D Flip flops (Truth Table & Excitation table only) Counters: Introduction to Up/Down Counter, Ripple Counter, Ring Counter Registers: Definition and Types Data Converter: Digital to Analog and Analog to Digital Converters	10
Unit - IV	**Semiconductor diode**: Rectifying diode Review of P-type and N-type semiconductor Junction of P-type & N type i.e., PN junction Barrier voltage, depletion region, Junction Capacitance. Forward biased & reversed biased junction Diode symbol, circuit diagram for V/S characteristics (forward & reversed) Characteristics of PN junction diode Specifications: - Forward voltage drop, Reversed saturation current, maximum forward current, power dissipation, Package view of diodes of different power ratings	12
Unit - V	**Bipolar Junction Transistor (BJT):** NPN and PNP Transistor – Operation and characteristics CB, CE, CC Configuration – characteristics and working **Biasing of BJT:** Introduction, need of biasing, concept of dc load line, selection of operating point (Q point), need of stabilization of Q point, (thermal run away concept) Types of biasing circuits: Fixed biased circuit, Base biased with emitter feedback, Base biased with collector feedback, Voltage divider, Emitter biased	**6**
Unit - VI	**Field Effect Transistor (FET):** FET – Working Principle, Classification, MOSFET Small Signal model, N-Channel/ P-Channel MOSFETs – characteristics, enhancement and depletion mode, MOFET as a Switch, Common Source Amplifiers Uni-Junction Transistor – equivalent circuit and operation	**6**
	Total	**48**

Reference Books:

1. Digital principles & Applications, Albert Paul Malvino & Donald P. Leach, McGraw Hill Education; Eighth edition ISBN: 978-9339203405
2. Digital Electronics, RogerL.Tokheim Macmillian, McGraw-Hill Education (ISE Editions); International 2 Revised edition ISBN: 978-0071167963
3. Digital Electronics – an introduction to theory and practice, William H. Gothmann, Prentice Hall India Learning Private Limited; 2 editions, ISBN: 978-8120303485
4. Electronics Devices and circuit theory, Boyestad & Nashel sky, Pearson Education India; 11 edition (2015), ISBN: 978-9332542600
5. Electronic Devices and Circuits, S. Salivahanan and N. Suresh Kumar, McGraw Hill Education; Fourth edition (1 July2017) ISBN: 978-9339219505
6. Electronics Devices & Circuits,Jacob Millman, McGraw Hill Education; 4 edition (2015), ISBN: 978-9339219543
7. Bell Electronics Devices & Circuits by J. David Prentice Hall of India
8. Basic Electronics Amit kumar FPH
9. Fundamentals of Basic Electronics Umesh Kumar FPH

Course Outcomes

After studying this course, the students would gain enough knowledge

1. Have a thorough understanding of the fundamental concepts and techniques used in digital electronics.
2. To understand and examine the structure of various number systems and its application in digital design.
3. The ability to understand, analyze and design various combinational and sequential circuits.
4. Ability to identify basic requirements for a design application and propose a cost-effective solution.
5. The ability to identify and prevent various hazards and timing problems in a digital design.
6. To develop skill for building and troubleshooting digital circuits.

****

INTRODUCTION TO ELECTRIC POWER GENERATION SYSTEMS LABORATORY
(ELECTRICAL ENGINEERING GROUP)

Subject Code	Practical						Credits
	No. of Periods Per Week			Full Marks	:	50	
	L	T	P	Internal(PA)	:	15	01
2020306	—	—	02	External(ESE)	:	35	

CONTENTS: PRACTICAL

Course Objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Maintain the efficient operation of various electric power generating plants.
- The capability to incorporate the knowledge of electrical power generation in other field of science, engineering and economics.

Practical's:

1. Identify the routine maintenance part of the coal fired thermal power plant and gas fired thermal power plant after watching a video programme.
2. Assemble and dismantle a small diesel generator power plant.
3. Identify the routine maintenance part soft he nuclear fired thermal power plant after watching a video programme.
4. Identify the routine maintenance part soft he large hydro power plant after watching a video programme
5. Identify the routine maintenance parts of the micro hydro power plant after watching a video programme.
6. Assemble a micro hydro power plant and then dismantle it.
7. Assemble and dismantle of the parabolic trough or parabolic dish Concentrated Solar Power (CSP)plant.
8. Assemble the solar PV plant to produce electric power and then dismantle it.
9. Assemble and dismantle a small biogas plant to generate electric power
10. Identify the routine maintenance parts of the large wind power plant after watching a video programme.
11. Assemble a horizontal axis small wind turbine to produce electric power
12. Dismantle a horizontal axis small wind turbine.
13. Assemble a vertical axis small wind turbine o produce electric power and then dismantle it.
14. Identify the routine maintenance part soft he horizontal axis small wind turbine after watching a video programme.
15. Identify the routine maintenance parts of the vertical axis small wind turbine after watching a video programme.

Course Outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry-oriented Cos associated with the above-mentioned competency:

a) Maintain the optimized working of the thermal power plant.
b) Maintain the optimized working of large and micro hydro power plants.
c) Maintain the optimized working of solar and biomass-based power plants.
d) Maintain the optimized working of wind power plants.
e) Select the adequate mix of power generation based on economic operation.

ELECTRIC CIRCUITS LABORATORY
(ELECTRICAL ENGINEERING GROUP)

<table>
<tr><td rowspan="4">Subject Code
2020307</td><td colspan="3">Practical</td><td colspan="3"></td><td>Credits</td></tr>
<tr><td colspan="3">No. of Periods Per Week</td><td>Full Marks</td><td>:</td><td>50</td><td rowspan="3">01</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>Internal(PA)</td><td>:</td><td>15</td></tr>
<tr><td>—</td><td>—</td><td>02</td><td>External(ESE)</td><td>:</td><td>35</td></tr>
</table>

CONTENTS: PRACTICAL

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Maintain electrical systems by applying AC and DC circuit fundamentals. Impart a basic knowledge of electrical quantities such as current, voltage, power, energy and frequency to understand the impact of technology in a global and societal context.
- Provide working knowledge for the analysis of basic DC and AC circuits used in electrical and electronic devices.

practical's

1. Use dual trace oscilloscope to determine A.C voltage and current response in given R L,C circuit.
2. Use voltmeter, ammeter, wattmeter to determine active, reactive and apparent power consumed in given R-L series circuit. Draw phase or diagram.
3. Use voltmeter, ammeter to determine active, reactive and apparent power consumed in given R-C series circuit. Draw phasor diagram.
4. Use voltmeter, ammeter, wattmeter to determine active, reactive and apparent power consumed in given R-L-C series circuit. Draw phase or diagram.
5. Use variable frequency supply to creature sonance in given series R-L-C circuit or by using variable inductor or variable capacitor.
6. Use voltmeter, ammeter, and wattmeter to determine current, power factor active, reactive and apparent power in R-C parallel A.C. circuit.
7. Use voltmeter, ammeter, wattmeter, power factor meter to determine current, p.f., active, reactive and apparent power for given R-L-C parallel circuit with series connection of resistor and inductor in parallel with capacitor.
8. Use variable frequency supply create resonance in given parallel R-L-C circuit or by using variable inductor or capacitor.
9. Use voltmeter, ammeter, wattmeter, pf meter to determine line and phase quantities of voltage and current for balanced three phases tar and delta connected load and calculate active, reactive, and apparent power. Draw phasor diagram.
10. Use voltmeter, ammeter, watt meter, pf meter to determine line and phase quantities of voltage and current for unbalanced three phases tar and delta connected load and calculate active, reactive, and apparent power. Draw phase or diagram.
11. Use voltmeter, ammeter to determine current through the given branch of electric network by applying mesh analysis.
12. Use voltmeter, ammeter to determine current through the given branch of electric network by applying node analysis.
13. Use voltmeter, ammeter to determine current through the given branch and voltage across the given element of circuit by applying superposition theorem.
14. Use voltmeter, ammeter to determine equivalent circuit parameter in a given circuit by applying Thevenin's theorem

15. Use voltmeter, ammeter to determine equivalent circuit parameter in a given circuit by applying Norton's theorem
16. Use voltmeter, ammeter to determine load resistance for maximum power transfer for a given circuit by applying maximum power transfer theorem.

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry-oriented project associated with the above-mentioned competency:

- Trouble shoot problems related to single phase A.C series circuits.
- Trouble shoot problems related to single phase A.C parallel circuits.
- Troubleshoot problems related to three phase circuits.
- Use principles of circuit analysis to trouble shoot electric circuits.
- Apply network theorems to troubleshoot electric circuits.

*****

WEB TECHNOLOGY LAB

SUBJECT CODE: 2018308	Practical			No. of period in one session:			Credits
	No. of Periods per Week			Full Marks:	:	25	01
	L	T	P/S				
		-	02	Internal(PA)	:	07	
				External(ESE)	:	18	

Course Learning Objectives:

This Lab course is intended to practice whatever is taught in theory class of ‘Web Technologies’. Some of the things that should necessary be covered in lab.

Course outcomes:

Student will be able to program web applications using and will be able to do the following:

- Use LAMP Stack for web applications
- Write simple applications with Technologies like HTML, Java script, AJAX, PHP
- Connect to Database and get results
- Parse XML files Student will be able to develop/build a functional website with full features.

Content: Practical		Hrs.	Marks
Unit – 1	Home page Development static pages (using Only HTML) of an online Book store.	04	
Unit – 2	Write a JavaScript to design a simple calculator to perform the following operations: sum, product, difference and quotient.	06	
Unit – 3	Write a PHP program to display a digital clock which displays the current time of the server.	06	
Unit – 4	Write an HTML code to display your CV on a web page.	04	
Unit – 5	Write an XML program to display products.	05	
Unit – 6	Create a web page with all types of Cascading style sheets.	06	
Unit – 7	Write a PHP program to display a digital clock which displays the current time of the server.	05	
Unit – 8	Write a JavaScript that calculates the squares and cubes of the numbers from 0 to 10 and outputs HTML text that displays the resulting values in an HTML table format.	04	

This is a skill course. More student practice and try to find solution on their own, better it will be.

Reference Books:

1. “Web Technologies--A Computer Science Perspective”, Jeffrey Jackson
2. “Internet & World Wide Web How to Program”, Deitel, Deitel, Goldberg, Pearson Education
3. “Web programming- Building Internet Application”, Chris Bales
4. Web Applications: Concepts and Real-World Design, Knuckles

ELECTRICAL AND ELECTRONIC MEASUREMENTS LABORATORY
(ELECTRICAL ENGINEERING GROUP)

Subject Code	Practical						Credits
2020309	No. of Periods Per Week			Full Marks	:	25	01
	L	T	P				
	—	—	02	Internal(PA)	:	07	
	—	—	—	External(ESE)	:	18	

CONTENTS: PRACTICAL

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Use relevant measuring instrument in different electrical applications.
- Identify the various parameters that are measurable in electronic instrumentation.
- Employ appropriate instruments to measure given sets of parameters.
- Practice the construction of testing and measuring set up for electronic systems.
- To have a deep understanding about instrumentation concepts which can be applied to Control systems.

Practical's:

1. Identify measuring instruments on the basis of symbol son dial, type, accuracy, class position and scale.
2. Identify the components of PMMC and MI instruments.
3. Troubleshoot PMMC and MI instruments.
4. Measure AC and DC quantities in a working circuit.
5. Extend range of ammeter and volt meter by using (i) shunt and multiplier (ii) CT and PT.
6. Use Clamp-on meter for measurement of AC/DC current, AC/DC voltage.
7. Use electro-dynamic watt-meter for measurement of power in a single-phase circuit
8. Troubleshoot electro dynamic watt-meter for measurement of power in a single-phasecircuit
9. Use single watt meter for measurement of active and reactive power of three phase balanced load.
10. Use two watt-meters for measuring active power of three-phase balanced load.
11. Calibrate single phase electronic energy meter by direct loading.
12. Troubleshoot single phase electronic energy meter.
13. Use digital multi-meter for measurement of AC/DC current, AC/DC voltage.
14. Use Kelvin's double bridge for measurement of low resistance.
15. Use voltmeter and ammeter method for measurement of medium resistance.
16. Use Megger for insulation resistance measurements.
17. Use earth tester for measurement of earth resistance.
18. Use CRO for the Measurement of supply frequency in single-phase circuit.
19. Use Tri-vector meter for measuring kW, and kVA of a power line.

COURSE OUTCOMES:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry-oriented Cos associated with the above-mentioned competency:

a) Check the working of the electrical measuring instrument.
b) Usedifferenttypesofmeasuringinstrumentsformeasuringvoltageandcurrent.
c) Usedifferenttypesofmeasuringinstrumentsformeasuringelectricpower

ELECTRIC MOTORS AND TRANSFORMERS LABORATORY
(ELECTRICAL ENGINEERING GROUP)

Subject Code 2020310	Practical						Credits
	No. of Periods Per Week			Full Marks	:	50	01
	L	T	P	Internal(PA)	:	15	
	—	—	02	External(ESE)	:	35	

CONTENTS: PRACTICAL

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Provide the basic concept of DC machines and Transformers.
- Develop the skills of the students in the areas of machines and transformers by identifying the current problem in the industries and bring solutions through research.
- Diagnose the condition of DC machines and Transformers.
- Maintain electric motors and transformers.

Practical's:

1. Dismantle a DC machine.
2. Reverse the direction of rotation of the DC shunt motor.
3. Perform brake test on DC shunt motor.
4. Control the speed of DC shunt motor by different methods.
5. Control the speed of DC series motor by different methods.
6. Perform the brake test on DC series motor.
7. Check the functioning of single-phase transformer.
8. Determine regulation and efficiency of single-phase transformer by direct loading.
9. Perform open circuit and short circuit test on single phase transformer to determine equivalent circuit constants, voltage regulation and efficiency.
10. Perform parallel operation of two single phase transformers to determine the load current sharing.
11. Performparalleloperationoftwosinglephasetransformersanddeterminetheapparentandrealpower load sharing.
12. Performpolaritytestonasingle-phasetransformerwhosepolaritymarkingsaremasked.
13. Performphasingouttestonathree-phasetransformerwhosephasemarkingsaremasked.
14. Connecttheauto-transformerinstep-upandstep-downmodesnotingtheinput/outputreadings.
15. Check the functioning of the CT, PT and isolation transformer.
16. Test the pulse transformer.

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry-oriented Cos associated with the above-mentioned competency:

a) Maintain different types of DC generators.
b) Maintain different types of DC motors.
c) Maintain single phase transformer.
d) Maintain three phase transformers.
e) Maintain different types of special purpose transformers used in different applications.

PYTHON (Term Work)

(ELECTRICAL ENGINEERING GROUP)

Subject Code 2018311	Term Work						Credits
	No. of Periods Per Week			Full Marks	:	25	01
	L	T	P/TW				
	—	—	02	Internal(PA)	:	07	
	—	—	—	External(ESE)	:	18	

CONTENTS: Practical		Hrs.	Marks
UNIT – 01	Write a program to demonstrate basic data type in python.		
UNIT – 02	Write a program to compute distance between two points taking input from the user (Pythagorean Theorem)		
UNIT – 03	Write a python program Using for loop, write a program that prints out the decimal equivalent of 1+½+1/3….1/n		
UNIT – 04	Write a Python program to find first n prime numbers. Write a program to demonstrate list and tuple in python.		
UNIT – 05	Write a program using a for loop that loops over a sequence. Write a program using a while loop that asks the user for a number and prints a countdown from that number to zero.		
UNIT – 06	Write a Python Program to add matrices. Write a Python program to multiply matrices.		
UNIT – 07	Write a Python program to check if a string is palindrome or not.		
UNIT – 08	Write a Python program to Extract Unique values dictionary values		
UNIT – 09	Write a Python program to read file word by word Write a Python program to Get number of characters, words.		
UNIT – 10	Write a Python program for Linear Search		

References Books:

1. Taming Python by Programming, Jeeva Jose, Khanna Publishing House
2. Starting Out with Python, Tony Gaddis, Pearson
3. Core Python Programming, Wesley J. Chun, Prentice Hall
4. Python Programming: Using Problem Solving Approach, Reema Thareja, Oxford University
5. Introduction to Computation and Programming Using Python. John V. Guttag, MIT Press.

Fundamentals of Basic electronics &Digital Electronics Term Work

(ELECTRICAL ENGINEERING GROUP)

Subject Code 2020312	Practical						Credits
	No. of Periods Per Week			Full Marks	:	25	01
	L	T	P/TW	Internal(PA)	:	07	
	—	—	04	External(ESE)	:	18	

CONTENTS: PRACTICAL

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- To acquire the basic knowledge of digital logic levels and application of knowledge to understand digital electronics circuits.
- To prepare students to perform the analysis and design of various digital electronic circuits.

Term Work:

1. To verify the truth tables for all logic fates – NOT OR AND NAND NOR XOR XNOR using CMOS Logic gates and TTL Logic Gates
2. Implement and realize Boolean Expressions with Logic Gates
3. Implement Half Adder, Full Adder, Half Subtractor, Full Subtractor using ICs.
4. Design and development of Multiplexer and De-multiplexer using multiplexer ICs.
5. Verification of the function of SR, D, JK and T Flip Flops.
6. To plot Forward & Reverse biased characteristics of diode.
7. To Plot Input & output characteristics of transistor in CE mode.
8. To Plot Input & output characteristics of transistor in CB mode.
9. To Plot Characteristics of FET.

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry-oriented Cos associated with the above-mentioned competency:

1. Have a thorough understanding of the fundamental concepts and techniques used in digital electronics.

2. To understand and examine the structure of various number systems and its application in digital design.

3. The ability to understand, analyze and design various combinational and sequential circuits.

4. Ability to identify basic requirements for a design application and propose a cost-effective solution.

5. The ability to identify and prevent various hazards and timing problems in a digital design.

6. To develop skill to build, and troubleshoot digital circuits.

STATE BOARD OF TECHNICAL EDUCATION, BIHAR

Scheme of Teaching and Examinations for

IVth SEMESTER DIPLOMA IN ELECTRICAL ENGINEERING/ ELECTRICAL & ELECTRONICS ENGINEERING.

(Effective from Session 2020-21 Batch) (Rev 1.0)

THEORY

Sr. No.	SUBJECT	SUBJECT CODE	TEACHING SCHEME	EXAMINATION-SCHEME							
			Periods per Week	Hours of Exam.	Teacher's Assessment (TA) Marks A	Class Test (CT) Marks B	End Semester Exam. (ESE) Marks C	Total Marks (A+B+C)	Pass Marks ESE	Pass Marks in the Subject	Credits
1.	Power Electronics	2020401	03	03	10	20	70	100	28	40	03
2.	Electric Power Transmission and Distribution	2020402	03	03	10	20	70	100	28	40	03
3.	Induction, Synchronous and Special Electrical Machines	2020403	03	03	10	20	70	100	28	40	03
4.	Solar Power technologies	2020404	03	03	10	20	70	100	28	40	03
5.	Industrial drives	2020405	03	03	10	20	70	100	28	40	03
	Total: - 15						**350**	**500**			**15**

PRACTICAL

Sr. No.	SUBJECT	SUBJECT CODE	TEACHING SCHEME	EXAMINATION-SCHEME					
			Periods per Week	Hours of Exam.	Practical: Internal (PA)	Practical: External (ESE)	Total Marks (A+B)	Pass Marks in the Subject	Credits
6.	Power Electronics Laboratory	2020406	02 50% physical 50% Virtual	03	15	35	50	20	01
7.	Induction, Synchronous and Special Electrical Machines Laboratory	2020407	02 50% physical 50% Virtual	03	15	35	50	20	01
8.	Industrial Drives laboratory	2020408	02 50% physical 50% Virtual	03	07	18	25	10	01
9.	MATLAB	2020409	02 50% physical 50% Virtual	03	07	18	25	10	01
	Total: - 08						**150**		04

TERM WORK

Sr. No.	SUBJECT	SUBJECT CODE	TEACHING SCHEME	EXAMINATION-SCHEME				
			Periods per Week	Marks of Internal (PA)	Marks of External (ESE)	Total Marks (X+Y)	Pass Marks in the Subject	Credits
10.	Electric power transmission and distribution (T.W)	2020410	02	07	18	25	10	01`
11.	Solar power technologies (T.W)	2020411	02	07	18	25	10	01
12.	Course Under Moocs /SWAYAM/**AutoCAD** in electrical engineering or others	2020412	02	07	18	25	10	01
13.	Summer training/Industrial Visits	2020413	04	07	18	25	10	02
	Total: - 10					**100**		**05**
	Total Periods per week Each of duration One Hour 33			Total Marks = **750**				**24**

POWER ELECTRONICS
(ELECTRICAL ENGINEERING GROUP)

Subject Code	Theory						Credits
2020401	No. of Periods Per Week			Full Marks	:	100	03
	L	T	P/S	ESE	:	70	
	03	—	—	TA	:	10	
	—	—	—	CT	:	20	

Course Objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- To understand and acquire knowledge about various power semiconductor devices.
- Maintain the proper functioning of power electronic devices
- To analyze and design different power electronics circuits such as power converters, inverters, choppers etc.

CONTENTS: THEORY

Chapter	Name of the Topic	Hrs.
Unit-1	**Power Electronic Devices** 1.1 Power electronic devices 1.2 Power transistor: construction, working principle, V-I characteristics and its applications. 1.3 FET & MOSFET: construction, working principle, V-I characteristics and its applications 1.4 IGBT: Construction, working principle, V-I characteristics and its applications.	04
Unit-2	**Thyristor Family Devices** 2.1 SCR: construction, types, working and its V-I characteristics. Two-transistor analogy, Protection circuits: Over-voltage, over-current, Snubber, Crowbar. 2.2 SCR mounting, cooling. &Rating 2.3 Thyristor family devices: symbol, construction, operating principle and V-I Characteristics of GTO, UJT, DIAC and TRIAC.	08
Unit-3	**Turn-on and Turn-off Methods of Thyristors** 3.1 SCR Turn-On methods: High Voltage triggering, thermal triggering, Illumination triggering, dv/dt triggering, Gate triggering. 3.2 Gate trigger circuits – Resistance and Resistance-Capacitance circuits. 3.3 SCR triggering using UJT Relaxation Oscillator and Synchronized UJT circuit. 3.4 SCR Turn-Off methods: Natural and forced commutation, Class A- Series resonant commutation circuit, Class B-Shunt Resonant commutation circuit, Class C-Complimentary Symmetry commutation circuit, Class D–Auxiliary commutation. (Only introduction derivation not required)	08
Unit-4	**Phase Controlled Rectifiers** 4.1 Phase control: firing angle, conduction angle. 4.2 Single Phase Fully Controlled Half Wave Converter - With R, RL load with dc source: Circuit diagram, working, input- output waveforms, equations for DC output and effect of freewheeling diode. 4.3 Single-phase full- wave mid-point and bridge converter with R, RL load with dc source: Circuit diagram, working, input- output waveforms, equations for DC output and effect of freewheeling diode. 4.4 Single-phase semi converter with R, RL load with dc source: Circuit diagram, working, input- output waveforms, equations for DC output and effect of freewheeling diode.	16

	4.5 Three-phase full converter with R, RL load with dc source: Circuit diagram, working, input- output waveforms, equations for DC output and effect of freewheeling diode. 4.6 Dual converter.	
Unit-5	**Chopper** – 5.1 Chopper Principle 5.2 Control Techniques: 1. Constant Frequency System 2.Variable Frequency System 5.3 Classification of Choppers: 5.4 Step Up Chopper & stepdown choppers with problems 5.5 Class A, Class B, Class C, Class D and Class E chopper 5.6 Commutation Methods for Choppers: Auxiliary Commutation & Load Commutation	04
Unit-6	**Inverters** 6.1 Single Phase Bridge Inverter - Half Bridge Inverter - Full Bridge Inverter 6.2 Three phase bridge inverters 6.3 Three phase 180 Degree mode VSI Circuit diagram, working, input- output wave forms, equations 6.4 Three phase 120-Degree mode VSI Circuit diagram, working, input- output wave forms, equations 6.5 Series Inverter - Operation of Basic Series Inverter Circuit and its application. 6.6 Parallel Inverter - Operation of Basic Parallel Inverter Circuit. 6.7 Cycloconverters principle of operation, Input output waveforms.	08
	TOTAL	**48**

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry-oriented Cos associated with the above-mentioned competency:

CO 1 : Select a suitable power electronics device for a given application.

CO 2 : Choose a suitable turn on & turnoff circuit for a thyristor for a given application

CO 3 : Use different types of power electronic converters for a given application

CO 4 : Select a suitable chopper for a given application.

CO 5 : Choose an appropriate inverter for a given application

CO PO MAPPING:

Course code.CO number	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2
C2020401.1	Select a suitable power electronics device for a given application	**2**	**3**		**-**	**-**	**1**	**--**	**-**	**-**
C2020401.2	Choose a suitable turn on & turnoff circuit for a thyristor for a given application	**2**	**3**		**-**	**-**	**1**	**-**	**-**	**-**
C2020401.3	Use different types of power electronic converters for a given application	**3**	**3**		**-**	**-**	**-**	**-**	**-**	**-**
C2020401.4	Select a suitable chopper for a given application	**2**	**3**		**-**	**-**	**1**	**-**	**-**	**-**

C2020401.5	Choose an appropriate inverter for a given application	**2**	**3**		**-**	**-**	**1**	**-**	**-**	**-**
C2020401 (Average)		**2.2**	**3**				**1**	**-**	**-**	**-**

Enter correlation levels 1, 2 or 3 as :
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation, Then put "-"

References:

1. An Introduction to Thyristor sand their applications, by M.Ramamoorty,East-West Press Pvt. Ltd., New Delhi, ISBN: 8185336679.
2. Thyristors: Theory and Applications, Sugandhi, Rajendra Kumar and Sugandhi, Krishna Kumar, New Age International(P) ltd. Publishers, New Delhi, ISBN:978-0-85226-852-0.
3. Power Electronics Circuits Devices and Applications by P.S. bhimbra
4. Fundamentals of Power Electronics, by S.K Bhattacharya, Vikas Publishing House Pvt. Ltd. Noida. ISBN:978- 8125918530.
5. Power Electronics and its Applications, by Jain & Alok,Penram International Publishing(India) Pvt. Ltd, Mumbai, ISBN: 978-8187972228.
6. Power Electronics Circuits Devices and Applications, by Muhammad Rashid, Pearson Education India, Noida, ISBN:978- 0133125900.
7. Power Electronics, by M.D. Singh, and K.B., Khan chandani, Tata McGraw Hill Publishing Co. Ltd, New Delhi, 2008ISBN: 9780070583894.
8. Z bar, Paul B., Industrial Electronics: A Text– Lab Manual, McGraw Hill Publishing Co. Ltd., New Delhi, ISBN: 978-0070728226.
9. Grafham D.R., SCR Manual, General Electric Co., ISBN:978-0137967711.
10. R N Duha , Power Electronics , FPH
11. R S Gupta , Fundamentals of Power Electronics , FPH

ELECTRIC POWER TRANSMISSION AND DISTRIBUTION (ELECTRICAL ENGINEERING GROUP)

Subject Code	Theory						Credits
2020402	No. of Periods Per Week			Full Marks	:	100	03
	L	T	P/S	ESE	:	70	
	03	—	—	TA	:	10	
	—	—	—	CT	:	20	

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- To introduce the students to the general structure of the network for transmitting power from generating stations to the consumers.
- To expose the students to the different electrical & mechanical aspects of the power network along with its environmental and safety constraints
- Maintain the proper functioning of the electrical transmission and distribution systems.

CONTENTS: THEORY

Chapter	Name of the Topic	Hrs.
Unit-1	**Basics of Transmission and Distribution** 1.1 Single line diagrams with components of the electric supply transmission and distribution systems. 1.2 Classification of transmission lines: Primary and secondary transmission; standard voltage level used in India. 1.3 Classification of transmission lines: based on the type of voltage, voltage level, length and others Characteristics of high voltage for power transmission. 1.4 Comparisons of transmission & distribution lines (methods of construction, ac and dc)	06
Unit-2	**Transmission Line Parameters and Performance** 2.1 Line Parameters: Concepts of R, Land C of line parameters and types of lines. Skin effect, proximity effect and Transposition of conductors and its necessity. 2.2 Performance of short line: Efficiency, regulation and its derivation, effect of power factor, vector diagram for different power factor, Numerical based on short transmission line. 2.3 Performance of medium line: representation, nominal ‘T’, nominal ‘π’ and end condenser methods. Ferranti effect.	10
Unit-3	**Extra High Voltage Transmission** 3.1 Extra High Voltage AC (EHVAC) transmission line**:** Necessity, high voltage substation components such as transformers and other switchgears, advantages, limitations and applications and lines in India. 3.2 High Voltage DC (HVDC) Transmission Line**:** Necessity, components, advantages, limitations and applications. Layout of mono polar, bi-Polar and homo-polar transmission lines in India. Features of EHVAC and HVDC transmission line. 3.3 Flexible AC Transmission line: Features, & types of FACTS controller. 3.4 New trends in (FACTS) wireless transmission of electrical power.	06

Unit-4	**A.C Distribution System** 4.1 AC distribution and DC distribution: Component's classification, requirements of an ideal distribution system, primary and secondary distribution system. 4.2 Feeder and distributor, factors to be considered in design of feeder and distributor. 4.3 Types of different distribution schemes: radial, ring, and grid, layout, advantages, disadvantages and applications. 4.4 Voltage drops, sending end and receiving end voltage. 4.5 Numerical based on dc distribution.	10
Unit-5	**Components of Transmission and Distribution Line** 5.1 Overhead Conductors**:** Properties of material, Types of conductors: Copper, Aluminum, ACSR, Solid, Stranded & bundled conductors and its properties with tradenames, Line supports Requirements, types of line structures and their specifications, methods of erection. 5.2 Line Insulators**:** Properties of insulating material, selection of material, types of insulators and their applications, causes of insulator failure, derivation of equation of string efficiency for string of three suspension insulator, method so fim proving string efficiency. 5.3 Introduction to SAG and Spacing between Conductors. Calculation of Span length & sag Calculation 5.4 Corona – corona formation, advantages & disadvantages, factors affecting corona, 5.5 Underground Cables**:** Requirements, classification, construction, comparison with overhead lines, cable laying and cable jointing	12
Unit -6	6.1 Distribution Sub-Station: Classification of **of indoor & outdoor sub-stations (33/11kv & 11kv/440v).** 6.2 Functions of their components. Site selection, advantages of distribution substation, disadvantages of distribution substation and its applications.	**04**
	Total	48

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry-oriented Cos associated with the above-mentioned competency:

CO 1 : Interpret the normal operation of the electric transmission and distribution systems.

CO 2 : Maintain the functioning of the medium and high voltage transmission system.

CO 3 : Interpret the para meters of the extra high voltage transmission system.

CO 4 : Maintain the components of the transmission and distribution lines.

CO PO MAPPING:

Course code.CO number	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2
C2020402.1	Interpret the normal operation of the electrictransmission and distribution systems.	3	3	2	2	3	2	2	2	1
C2020402.2	Maintain the functioning of the medium andhigh voltage transmission system.	3	2	-	2	2	-	3	2	2
C2020402.3	Interpret the parameters of the extra highvoltage transmission system.	3	3	2	2	3	2	2	1	-
C2020402.4	Maintain the components of the transmissionand distribution lines.	3	2	1	2	3	2	2	3	2
C2020402 (Average)		3	2.5	1.25	2	2.75	1.5	2.25	2	1.25

Enter correlation levels 1, 2 or 3 as :
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation, Then put "-"

References:

1. Utilization of Electric Power & Electric Traction, byG.C. Garg, Khanna Book Publishing Co., New Delhi(ISBN:978- 93-86173-355)
2. Principles of Power System, by V.K. Mehta, S.Chand and Co. New Delhi, ISBN:9788121924962
3. A Course in Electrical Power, by Soni; Gupta; Bhatnagar, Dhanpat Rai and Sons New Delhi, ISBN:9788177000207
4. A Course in Power Systems, byJ.B.Gupta.,S.K.Katariaandsons,NewDelhi,ISBN:9788188458523
5. A.K., A Textbook of Electrical Technology Vol. III, by B.L. The raja S. Chand and Co. New Delhi, ISBN: 9788121924900
6. A Course in Electrical Power, by S.L. Uppal S.K. Khanna Publisher New Delhi, ISBN:9788174092380
7. Electrical Power Transmission and Distribution, by S. Satyanarayana S. pearsons education,NewDelhi,ISBN:9788131707913
8. Ned Mohan, Electrical Power System: A First Course, Wiley India Pvt. Ltd. New Delhi, ISBN:9788126541959
9. Gupta, B.R., Power System Analysis and Design, Chand and Co. New Delhi, ISBN:9788121922388
10. Electrical Power Distribution System, by V Kam raju, Tata McGraw-Hill, New Delhi, ISBN:9780070151413
11. Piyush Goyal , Electric Power Transmission and Distribution ,Foundation Publishing House.

INDUCTION, SYNCHRONOUS AND SPECIAL ELECTRIC MACHINES
(ELECTRICAL ENGINEERING GROUP)

Subject Code	Theory						Credits
2020403	No. of Periods Per Week			Full Marks	:	100	03
	L	T	P/S	ESE	:	70	
	03	—	—	TA	:	10	
	—	—	—	CT	:	20	

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experience.

- To expose the concepts of energy conversion theory between electrical and mechanical systems by introducing electromechanical energy conversion principles.
- To impart knowledge on construction principle of operation and performance of synchronous motor as well alternator.
- To expose the concepts of single and three phase induction motor and its industrial applications.
- Maintain Induction, Synchronous and FHP Machines used in different applications.

CONTENTS: THEORY

	Name of the Topic	Hrs./Unit
Unit-01	**Three Phase Induction Motor** 1.1 Working principle: production of rotating magnetic field, Synchronous speed, rotor speed and slip. 1.2 Constructional details of 3 phase induction motors: Squirrel cage induction motor and Slip ring induction motor. 1.3 Rotor quantities: frequency, induced emf, power factor at starting and running condition. 1.4 Characteristics of torque versus slip (speed), Torques: starting, full load and maximum with Relations among them. 1.5 Induction motor as a generalized transformer with phasor diagram. Four quadrant operation, Power flow diagram Starters: need and types; stator resistance, auto transformer, star delta, rotor resistance and soft starters. 1.6 Speed control methods: stator voltage, pole changing, rotor resistance and VVVF. Motors selection for different applications as per the load torque-speed requirements. 1.7 Maintenance of three phase induction motors	16
Unit-02	**Single phase induction motors** 2.1 Double field revolving theory, principle of making these motors self-start. 2.2 Construction and working: Resistance start induction run, capacitor start induction run, capacitor start capacitor run, shaded pole, repulsion type, series motor, universal motor, hysteresis motor. 2.3 Torque-speed characteristics for all of the above motors. 2.4 Motor selection for different applications as per the load torque-speed requirements. Maintenance of single-phase induction motors	08

Unit-03	**Three phase Alternators** 3.1 Principle of working, moving and stationary armatures. 3.2 Constructional details: parts and their functions, rotor constructions. Windings: Single and Double layer. 3.3 E.M. F. equation of an Alternator with numerical by considering short pitch factor and distribution factor. 3.4 Alternator loading: Factors affecting the terminal voltage of alternator; Armature resistance and leakage reactance drops. 3.5 Armature reaction at various power factors and synchronous impedance. Voltage regulation: direct loading and synchronous impedance methods. Maintenance of alternators	10

Unit-04	**Synchronous motors** 4.1 Principle of working /operation, significance of load angle. 4.2 Torques: starting torque, running torque, pull in torque, pull out torque. Synchronous motor on load with constant excitation(numerical), effect of excitation at constant load (numerical). 4.3 V-Curves and Inverted V-Curves. 4.4 Hunting and Phase swinging. 4.5 Methods of Starting of Synchronous Motor. 4.6 Losses in synchronous motors and efficiency (no numerical). 4.7 Applications areas	08
Unit-05	**Fractional horse power (FHP) Motors** 5.1 Construction and working: Synchronous Reluctance Motor, Switched Reluctance Motor, BLDC, Permanent Magnet Synchronous Motors, stepper motors, AC and DC servomotors. 5.2 Torque speed characteristics of above motors. Applications of above motors	06
	Total	**48**

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry-oriented Cos associated with the above-mentioned competency:

CO 1 : Explain three phase induction motor used in different applications.

CO 2 : Select single-phase induction motor used in different applications.

CO 3 : Use various three phase alternators used in different applications.

CO 4 : Maintain synchronous motors used in different applications.

CO 5 : 5 Select FHP motors used in different applications

CO PO MAPPING:

Course code.CO number	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2
C2020403.1	Explain three phase induction motor used in different applications	3	1	-	-	2	3	2	2	-
C2020403.2	Select single-phase induction motor used in different applications	3	2	1	3	-	1	1	2	3
C2020403.3	Use various three phase alternators used in different applications	3	-	-	3	1	2	1	3	2
C2020403.4	Maintain synchronous motors used in different applications	3	-	-	3	1	2	1	3	2
C2020403.4	Select FHP motors used in different applications	3	1	1	3	1	1	2	3	3
C2020403 (Average)		3	1	0.5	2.25	1	1.75	1.5	2.5	2

Enter correlation levels 1, 2 or 3 as :
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation, Then put "-"

References:

1. Electric Machines, by P.S. Bimbhra, Khanna Book Publishing Co., New Delhi(ISBN:978-93-86173-294)
2. Basic Electrical Engineering, by V. N. and Mittal,Arvind., McGraw Hill Education New Delhi, ISBN :9780070593572
3. Electrical Machines, by Kothari and Nagrath, McGraw Hill Education. New Delhi, ISBN: 9780070699670
4. Electrical Machines, by S.K. Bhattacharya, McGraw Hill Education, New Delhi, ISBN:9789332902855
5. Electrical Technology Vol-II (AC and DC machines), by , B.L The raja S. Chand and Co. Ltd. New Delhi, ISBN: 9788121924375
6. Sen, S. K., Special Purpose Electrical Machines, Khanna Publishers, New Delhi, ISBN:9788174091529
7. Janardan an E.G, Special Electrical Machines, Prentice Hall India, New Delhi ISBN:9788120348806
8. Hughes E., Electrical Technology, ELBS
9. Cotton H., Electrical Technology, ELBS
10. S K Agarwal , Induction, Synchronous and Special Electrical Machines , Foundation Publishing House
11. Vikas Kumar , Electrical Engineering , Foundation Publishing House.

SOLAR POWER TECHNOLOGIES
(ELECTRICAL ENGINEERING GROUP)

Subject Code	Theory						Credits
2020404	No. of Periods Per Week			Full Marks	:	100	03
	L	T	P/S	ESE	:	70	
	03	—	—	TA	:	10	
	—	—	—	CT	:	20	

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- To develop a comprehensive technological understanding in solar PV system components
- To provide in-depth understanding of design parameters to help design and simulate the performance of a solar PV power plant
- To pertain knowledge about planning, project implementation and operation of solar PV power generation.
- Maintain the efficiency and operation of various types of solar power technologies

CONTENTS: THEORY

Chapter	Name of the Topic	Hrs.
Unit-01	**Solar Energy** 1.1 Solar Map of India: Global solar power radiation 1.2 Different types of Solar water heaters: Construction, working, specifications and installation. 1.3 Solar Heating systems, solar drying and different types of solar cookers solar lighting. 1.4 Preventive maintenance of all of the above.	8
Unit-02	**Concentrated Solar Power (CSP)** 2.1 Concentrated Solar Power (CSP) plants or solar thermal electric systems 2.2 Parabolic Trough: Construction, working and specifications 2.3 Parabolic Dish: Construction, working and specifications 2.4 Power Tower, Fresnel Reflectors: Construction, working and specifications Solar Sterling engines 2.5 Preventive maintenance of all of the above	12
Unit-03	**Solar PV Systems** 3.1 Solar PV cell: Types construction, working, typical specifications of solar cells 3.2 Solar PV working principle: Series and parallel connections of solar modules Solar Photovoltaic (PV)system: components layout and working. 3.3 Solar modules, arrays and their standard specifications Roof top and street light 3.4 Solar PV systems and typical specifications 3.5 Maintenance of these systems	10
Unit-04	**Solar PV Electronics** 4.1 Solar Charge controllers: working and specifications, 4.2 Switch gear and cables Batteries: Different types for solar PV systems, 4.3 Maintenance and specifications 4.4 Solar Inverters: working and specifications 4.5 Signal conditioning systems: working and specifications 4.6 Solar Power tracking: construction, working, tilt angle, solar radiation, I-V, P-V characteristics, maximum power point tracking (MPPT) 4.7 Maintenance of these systems.	10

Unit-05	**Solar PV Off-grid and Grid Tied Systems** 5.1 Solar off grid systems: layout and specifications 5.2 Solar Grid tied (on grid) systems: Working principle of grid-tied dc-ac inverter, 5.3 Grid synchronization and active power export net metering: main features and working 5.4 Solar wind Hybrid systems: Layout and specifications.	08
	Total	48

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented CO associated with the above mentioned competency:

CO 1 : Distinguish different types of Solar Energy application like Solar Water Heater, Solar heating system, solar drying system, Solar cooker. Describe their preventive maintenance.

CO 2 : Identify different types of solar PV system

CO 3 : Maintenance of different types of Solar PV system

CO 4 : Explain the working of Solar PV electronics and MPPT system.

CO 5 : Explain the need of Off grid and On grid system. Describe is layout and working system

CO PO MAPPING:

Course code.CO number	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2
C2020404.1	Distinguish different types of Solar Energy application like Solar Water Heater, Solar heating system, solar drying system, Solar cooker. Describe their preventive maintenance.	3	3	1	-	-	-	-	-	-
C2020404.2	Identify different types of solar PV system.	3	3	-	-	-	-	-	-	-
C2020404.3	Maintenance of different types of Solar PV system	3	3	-	-	-	-	-	-	-
C2020404.4	Explain the working of Solar PV electronics and MPPT system.	3	3	-	-	-	-	-	-	-
C2020404.5	Explain the need of Off grid and On grid system. Describe is layout and working system	3	3	2						
C2020404 (Average)		3	3	1						

Enter correlation levels 1, 2 or 3 as :
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation, Then put "-"

References:

1. Solar Photovoltaic Technology and Systems-A Manual For Technicians, Trainers and Engineers, BY Solanki, Chetan Singh, PHI Learning, New Delhi, ISBN: 9788120347113
2. Renewable Energy Sources and Emerging Technologies, by D.P Kothari, PHI
3. Renewable Energy Systems, by David M.Buchla, Thomas E. Kissell, Thomas L. Floyd,-Pearson Education New Delhi ,ISBN:9789332586826
4. Rachel, Sthuthi, Earnest, Joshua;-Wind Power Technologies, PHIL earning
5. Energy Technology, by O.P. Gupta, Khanna Publishing House, ISBN:978-93-86173-683
6. Solar Power Technologies , R.S. Swaminathan , FPH

INDUSTRIAL DRIVES
(ELECTRICAL ENGINEERING GROUP)

Subject Code	Theory						Credits
2020405	**No. of Periods Per Week**			**Full Marks**	**:**	**100**	**03**
	L	**T**	**P/S**	**ESE**	**:**	**70**	
	03	**—**	**—**	**TA**	**:**	**10**	
	—	**—**	**—**	**CT**	**:**	**20**	

Course Objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- To expose students to the operating principal application and control of power conversion systems employing electric drive to cater to industrial needs.
- To familiarize the operation principles, and design of starting, braking, and speed control arrangements for electric motors and their applications.
- To provide strong foundation to asses performance of different industrial drives considering issues such as, energy efficiency, power quality, economic justification, environmental issues, and practical viabilities.

CONTENTS: THEORY

Chapter	Name of the Topic	Hrs.
Unit-01	**Electric Drives** 1.1 Need of Electric Drives, Functional Block diagrams of an electric drives DC Motors, Motor Rating Series, Shunt and compound DC motors. 1.2 Universal motor Permanent magnet motor, DC servo motor, Moving coil motor, Torque motor, Starting and Braking of DC Motors, Brushless DC Motors for servo applications. 1.3 Maintenance procedure	10
Unit-02	**AC Motors** 2.1 Single phase AC Motors Resistance split phase motors, Capacitor run motors, Capacitor start motors, Shaded pole motors Three phase Induction Motors Squirrel cage Induction motor, Slip ring Induction Motor Starting methods of Induction Motor Braking methods of Induction, Motor Determination of Motor Rating 2.2 Maintenance procedure.	12
- Unit-03	**DC Drives** 3.1 Single phase SCR Drives, Half wave converter :Full wave converter, Semi converter & Dual converter 3.2 Three Phase SCR Drives: Half wave converter, Full wave converter, Semi converter Dual converter Reversible SCR Drives. Speed control methods of DC series Motor Chopper Controlled DC Drives Solar and battery powered vehicles 3.3 Maintenance procedure.	10
Unit-04	**AC Drives** 4.1 Starting and Braking of Induction motors Stator voltage control Variable Frequency Control, Voltage Source Inverter Control, Current Source Inverter Control, Rotor Resistance Control, Slip Power Recovery scheme. 4.2 Solar powered pump drives Maintenance procedure for AC drives Sequences of stages & drives required in each stage for following applications: Textile mills Steel rolling mills Paper mills Sugar mills	10

Unit-05	**Advanced Techniques of Motor Control** 5.1 Microcontroller/Microprocessor based control for drives Phase locked loop control of DC motor. 5.2 AC/DC motor drive using Microcomputer control AC / DC motor drive using Microcontroller control. 5.3 Synchronous Motor drives Ratings & specifications of stepper motor Stepper motor drives employing microcontroller (No programming).	06
	Total	48

Course Outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry-oriented Cos associated with the above-mentioned competency:

CO :1 Understanding about Electric Drives including DC motor and also about its maintenance.

CO :2 Select relevant AC motor for various electric drive applications.

CO :3 Maintain the operation of DC Drives.

CO :4 Maintain the operation of AC Drives.

CO :5 Maintain the operation of microprocessor/micro controlled electric motors.

CO PO MAPPING:

Course code.CO number	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2
C2020405.1	**Understanding about Electric Drives including DC motor and also about its maintenance.**	3	2	-	1	-	-	1	-	-
C2020405.2	**Understanding about the AC motors and Its maintenance procedure.**	3	2	-	1	-	-	1	-	-
C2020405.3	**Understanding about the DC drives including SCR drives.**	3	2	-	1	-	-	1	-	-
C2020405.4	**Understanding about the AC drives and also about the VSI, CSI, Rolling Mills.**	3	2	-	1	-	-	1	-	-
C2020405s.5	**Understanding about Advance technique of Motor Control.**	3	2	-	1	-	-	1	-	-
C2023022 (Average)		3	2	-	1	-	-	1	-	-

Enter correlation levels 1, 2 or 3 as :
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation, Then put "-"

References

1. Fundamentals of Electrical Engineering, by Saxena,S. BLal, K. Dasgupta, Cambridge university press pvt. Ltd., New Delhi, ISBN: 9781107464353
2. A Text Book of Electrical Technology Vol-II, by B.L. Theraja,A.K Theraja, S.Chandand Co. Ramnagar, New Delhi, ISBN:9788121924405
3. Basic Electrical Engineering, by V.N. Mittle, Arvind Mittle, McGraw Hill Education ,Noida ,ISBN: 9780070593572
4. Power Electronics, by P.C. Sen Mcgraw Hill Publishing Company Limited, New

Delhi.ISBN:9780074624005

5. Dubey Gopal K.,Fundamentals of Electrical Drives, Second Edition, Narosa Publishing House, New Delhi.ISBN:9788173194283
6. Subrahmanyam, Vedam, Electrical Drives Concepts and Applications, Mcgraw-Hill Publishing Company Limited, NewDelhi.ISBN:9780070701991
7. Agrawal , Jai P., Power Electronic Systems Theory and Design, Pearson Education, Inc. ISBN 9788177588859.
8. Design and Testing of Electrical Machines, Deshpande M.V., PHI Publication,ISBN:9788120336452
9. A first course on Electrical Drives by S.K.,Pillai,,WileyEasternLtd.NewDelhi,ISBN:13:978-0470213995
10. Industrial Drives , Rajesh Thakral , FPH

POWER ELECTRONICS LABORATORY
(ELECTRICAL ENGINEERING GROUP)

Subject Code	Practical						Credits
2020406	No. of Periods Per Week			Full Marks	:	50	01
	L	T	P	ESE	:	50	
	—	—	02	Internal (PA)	:	15	
	—	—	—	External (ESE)	:	35	

CONTENTS: PRACTICAL

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Maintain the proper functioning of power electronic devices.
- To understand and acquire knowledge about various power semiconductor devices.
- Maintain the proper functioning of power electronic devices
- To analyze and design different power electronics circuits

Practical's:

1. Test the proper functioning of power transistor.
2. Test the proper functioning of IGBT.
3. Test the proper functioning of DIAC to determine the break over voltage.
4. Determine the latching current and holding current using V-I characteristics of SCR.
5. Test the variation of R, C in R and R C triggering circuits on firing angle of SCR.
6. Test the effect of variation of R, C in UJT triggering technique.
7. Perform the operation of Class–A, B, C, turn off circuits.
8. Perform the operation of Class–D,E, F turn off circuits.
9. Use CRO to observe the output waveform of half wave-controlled rectifier with resistive load and determine the load voltage.
10. Draw the output wave form of Full wave controlled rectifier with R load, RL load, free wheeling diode and determine the load voltage.
11. Determine the firing angle using DIAC and TRIAC phase-controlled circuit on output power under different loads such as lamp, motor or heater
12. Simulate above firing angle control on SCIL AB software
13. Test the performance of given SMPS, UPS.
14. Troubleshoot the Burglar's alarm, Emergency light system, Speed control system, Temperature control system.

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented Cos associated with the above mentioned competency:

CO 1 : Troubleshoot various power electronic devices.

CO 2 : Maintain various power electronic devices

CO 3 : Maintain various phase-controlled rectifiers

CO 4 : Troubleshoot the firing circuits and turn off circuits of thyristor

CO 5 : Use SCILAB software to simulate firing angle control

CO PO MAPPING:

Course code.CO number	**CO Statement**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**
C2020406.1	Troubleshoot various power electronic devices	**3**	**-**	**--**	**3**	**-**	**2**	**2**	**-**	**-**
C2020406.2	Maintain various power electronic devices	**2**	**-**	**-**	**3**	**-**	**2**	**2**	**-**	**-**
C2020406.3	Maintain various phase-controlled rectifiers	**2**	**-**	**-**	**3**	**-**	**2**	**2**	**-**	**-**
C2020406.4	Troubleshoot the firing circuits and turn off circuits of thyristor	**3**	**-**	**-**	**3**	**-**	**2**	**2**	**-**	**-**
C2020406.5	Use SCILAB software to simulate firing angle control	**3**	**-**	**-**	**3**	**-**	**1**	**3**	**-**	**-**
C2020406 (Average)		**2.6**	**-**	**-**	**3**	**-**	**1.8**	**2.2**		

Enter correlation levels 1, 2 or 3 as :
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation, Then put "-"

INDUCTION, SYNCHRONOUS AND SPECIAL ELECTRIC MACHINES LABORATORY

(ELECTRICAL ENGINEERING GROUP)

Subject Code	Practical						Credits
2020407	No. of Periods Per Week			Full Marks	:	50	01
	L	T	P	ESE	:	50	
	—	—	02	Internal (PA)	:	15	
	—	—	—	External (ESE)	:	35	

CONTENTS: PRACTICAL

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- To expose the concepts of energy conversion theory between electrical and mechanical systems by introducing electromechanical energy conversion principles.
- To impart knowledge on construction principle of operation and performance of synchronous motor as well alternator.
- To expose the concepts of single and three phase induction motor and its industrial applications.
- Maintain Induction, Synchronous and FHPM a chines used in different applications.
  - Maintain Induction, Synchronous and FHPM a chines used in different applications.

Practical's:

1. Identify the different parts (along with function and materials) for the given single phase and three phase induction motor.
2. Connect and run the three-phases squirrel cage induction motors (in both directions) using the DOL star- delta, auto-transformer starters(any two)
3. Perform the direct load test on the three-phase squirrel cage induction motor and plot the
   i) Efficiency versus output, ii) power factor versus output, iii) power factor versus motor current and iv) torque – slip/speed characteristics.
4. Conduct the No-load and Blocked-rotor test son given3-phase squirrel cage induction motor and determine the equivalent circuit parameters.
5. Conduct the No-load and Blocked-rotor test son given3-phase squirrel cage induction motor and plot the Circle diagram.
6. Control the speed of the given three phase squirrel cage/slip ring induction motor using the applicable methods: i) auto-transformer, ii) VVVF.
7. Measure the open circuit voltage ratio of the three-phase slip ring induction motor.
8. Conduct the direct load test to determine the efficiency and speed regulation for different loads on the given single phase induction motor; plot the efficiency and speed regulation curves with respect to the output power.
9. Perform the direct loading test on the given three phase alternator and determine the regulation and efficiency.

10. Determine the regulation and efficiency of the given three phase alternators from OC and SC
tests (Synchronous impedance method)
11. Conduct the test on load or no-load top lot the ‘V’ curves and inverted ‘V’ curves
(atno -load) of 3 phase synchronous motor.
12. Dismantling and reassembling of single-phase motors used for ceiling fans, universal motor for mixer.
13. Control the speed and reverse the direction of stepper motor
14. Control the speed and reverse the direction of the AC servomotor
15. Control the speed and reverse the direction of the DC servomotor

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry-oriented Cos associated with the above mentioned competency:

CO 1 : Maintain three phase induction motor used in different applications.

CO 2 : Maintain single phase induction motor used in different applications.

CO 3 : Maintain three phase alternators used in different applications.

CO 4 : Maintain synchronous motors used in different applications.

CO 5 : Maintain FHP motors used in different applications.

CO PO MAPPING:

Course code.CO number	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2
C2020407.1	Maintain three phase induction motor used in different applications.	3	3	-	2	1	1	2	1	-
C2020407.2	Maintain single phase induction motor used in different applications.	3	3	-	2	1	1	2	1	-
C2020407.3	Maintain three phase alternators used in different applications.	3	3	-	2	1	1	2	1	-
C2020407.4	Maintain synchronous motors used in different applications.	3	3	-	2	1	1	2	1	-
C2020407.5	Maintain FHP motors used in different applications	3	3	-	2	1	1	2	1	-
C202407 (Average)		3	3	-	2	1	1	2	1	-

Enter correlation levels 1, 2 or 3 as :
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation, Then put “-”

****

INDUSTRIAL DRIVES LABORATORY
(ELECTRICAL ENGINEERING GROUP)

Subject Code 2020408	Term Work						Credits
	No. of Periods Per Week			Full Marks	:	50	01
	L	T	P	Internal (PA)	:	15	
	—	—	02	External (ESE)	:	35	

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- To expose students to the operation, application and control of power conversion systems employing electric drive to cater to industrial needs.
- To familiarize the operation principles, and design of starting, braking, and speed control arrangements for electric motors and their applications.
- To provide strong foundation to assess performance of different industrial drives considering issues such as, energy efficiency, power quality, economic justification, environmental issues, and practical viabilities.

Practical's:

1. Dismantle the given DC motor and identify its different parts
2. Dismantle the given AC motor and identify its different parts
3. Control the speed of DC Motor using armature voltage control method
4. Control the speed of DC Motor using field current control method
5. Measure the output voltage of chopper for resistive load by varying the frequency and /or duty cycle of chopper.
6. Control the speed of three phase squirrel cage induction motor using stator voltage control method.
7. Effect on speed of given D.C. series motor by varying armature voltage using stepdown chopper.
8. Observe the effect on speed of the given D.C. separately excited motor by varying voltage using step down chopper.
9. Control the speed of the given separately excited motor by changing the firing angle of SCR using single phase semi converter and measure the speed.
10. Control the speed of the given separately exited motor by changing the firing angle of SCR using single phase full converter and measure the speed
11. Control the speed of the given three phase induction motor by using constant V / f method and plot the graph between speed and frequency.
12. Control the speed of the given three phase induction motor by varying frequency and plot the graph between speed and frequency
13. Control the speed of the given synchronous motor drives using microcontroller.
14. Demonstrate High power SCR / power device and Heat sink and write their specifications and rating.
15. Control the speed of single-phase capacitor split phase induction motor using DIAC–TRIAC circuit.
16. Control the speed of DC motor drives using microcontroller.

17. Identify different parts and assemble the given DC motor.
18. Identify different parts and assemble the given AC motor.

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented Cos associated with the above mentioned competency:

CO 1 : Select relevant DC motor for various electric drive applications.

CO 2 : Select relevant AC motor for various electric drive applications.

CO 3 : Maintain Operation of DC Drives.

CO 4 : Maintain Operation of AC Drives.

CO 5 : Maintain the Operation microprocessor/micro controlled electric motors.

CO PO MAPPING:

Course code.CO number	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2
C2020408.1	Select relevant DC motor for various electric drive applications.	3	2	-	1	-	-	2	-	-
C2020408.2	Select relevant AC motor for various electric drive applications.	3	2	-	1	-	-	2	-	-
C2020408.3	Maintain the operation of DC Drives.	3	2	1	1	-	-	1	1	-
C2020408.4	Maintain the operation of AC Drives.	3	2	1	1	-	-	1	1	-
C2020408.5	Maintain the operation of microprocessor/micro controlled electric motors.	3	2	1	1	-	-	1	1	-
C2020408 (Average)		3	2	1	1	-	-	2	1	-

Enter correlation levels 1, 2 or 3 as :

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation, Then put “-”

****

MATLAB

Subject Code 2020409	Term Work						Credits
	No. of Periods Per Week			Full Marks	:	25	01
	L	T	P	Internal (PA)	:	07	
	—	—	02	External (ESE)	:	18	

Unit-1	1.1 MATLAB Environment – Introduction, MATLAB environment, MATLAB as a calculator, MATLAB Online, Syntax and Semantics, Help, Plotting. 1.2 Matrices and Operators : Introduction, the Colon Operator, Accessing Parts of a Matrix, Combining and Transforming Matrices, Arithmetic Part 1, Arithmetic Part 2, Operator Precedence.
Unit-2	2.1 Functions : Introduction, Function I/O, Formal Definition of Functions, Sub Functions, Scope, Advantages of Functions, Scripts, an Problem Solving.
Unit-3	3.1 Programmer's Toolbox : Introduction, Matrix Building, Input-Output, Plotting, Debugging, Selection : Selection, If – Statements, Relational and Logical Operators, Nested if – Statements, Variable Number of Function Arguments, Robustness, Persistent Variables.
Unit-4	4.1 Loops : For -Loops While – Loops, Break Statements, Logical Indexing. Data Types : Introduction, Strings, Structs, Cells.
Unit-5	5.1 File Input / Output : I/O, Excel Files, Text Files, Binary Files. Applications of MATLAB in Electrical Machine, Power system, Control System and Power Electronics.
Unit-6	6.1 Simulink : Getting Started, Simulink Library Browser, Connections, Block Specification, Toolboxes, Building Systems, Applications.

List of Practical's :

1.	Basic Operations on Matrices.
2.	Generation of Various Signals such as Unit impulse, unit step, square, saw tooth, triangular, sinusoidal, ramp etc.
3.	Operations on signals and sequences such as addition, multiplication, scaling, shifting, folding, computation of energy and average power.
4.	Mesh and Nodal analysis of electrical circuits.
5.	Application of network theorems such as Thevenin's, Norton's, Superposition etc. to electrical networks.
6.	Locating Zeroes and poles and plotting the pole-zero maps in S plane and for the given TF
7.	Simulation of DC circuits.
8.	Measurement of Active power of three phase circuit for balanced oads.
9.	Simulation of single-phase diode bridge rectifiers with filter for R and RL loads.

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented Cos associated with the above mentioned competency

1. To generate the sine wave usingMAT LAB
2. To generate the impulse signalusing MAT LAB
3. To find the displacement andpressure using LVDT and Bellous.
4. To find the Frequency responseof capacitive Transducer

CO PO MAPPING:

Course code.CO number	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2
C2020409.1	To generate the sine wave using MAT LAB.	3	1	1	2	1	-	1	2	1
C2020409.2	To generate the impulse signal using MAT LAB.	3	2	2	2	2	2	2	2	2
C2020409.3	To find the displacement and pressure using LVDT and Bellous.	2	1	2	2	1	1	2	2	1
C2020409.4	To find the Frequency response of capacitive Transducer.	3	2	2	1	1	-	1	2	1
C409 (Average)	To find the Loading effect and Frequency response of Piezo-electric effect.	3	2	2	1	1	1	1	2	2

Enter correlation levels 1, 2 or 3 as :
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation, Then put "-"

References / Text Books :

1. Books
   (i) Computer Programming with MATLAB by J. Michael Fitzpatrick and Akos Ledeczi
   (ii) Getting Started with MATLAB : A Quick Introduction for Scientists and Engineers by Rudra Pratap
2. Video Lectures (Web Links) :
   (1) https://ocw.mit.edu/courses/mathematics/18-s997-introduction-to-matlab-programming.fall2011/index.html
   (2) https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-094-introduction-tomatlab-january-jjap-2010/index.html.
   (3) https://in.mathworks.com/vidoes/getting-started-with-matlab-68985.html.
   (4) https://www.mathworks.com/examples/
   (5) https://www.coursera.org/learn/matlab

ELECTRIC POWER TRANSMISSION AND DISTRIBUTION (TW)
(ELECTRICAL ENGINEERING GROUP)

Subject Code 2020410	Term Work						Credits
	No. of Periods Per Week			Full Marks	:	25	01
	L	T	P	Internal (PA)	:	07	
	—	—	02	External (ESE)	:	18	

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- To introduce the students to the general structure of the network for transferring power from generating stations to the consumers.
- To expose the students to the different electrical & mechanical aspects of the power network along with its environmental and safety constraints
- Maintain the proper functioning of the electrical transmission and distribution systems.

Course contents:

Laboratory work is not applicable for this course.

Following are the suggested student related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various out comes in this course : Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect / record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Prepare a report based on transmission line networking Bihar.
b. Collect the information on components of transmission line.
c. Evaluate transmission line performance parameters of a given line.
d. Library/Internet survey of electrical high voltage line and HVDC lines.
e. Visit to 33/11KVand11KV/400VDistribution Substation and write a report

Also one micro-project can be assigned to the student. A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned faculty:

a. Prepare a model showing:
   i. Single line diagram of electric supply system.
   ii. Single line diagram of a given distribution system.
   iii. Short line and medium transmission line.
   iv. Write areport on the same by giving the details of lines in Bihar State.
b. Collect different samples of Overhead Conductors, Underground Cables, Line supports and Line Insulators.
c. Prepare a power point presentation:
   i. Extra High Voltage AC Transmission line.
   ii. High Voltage DC Transmission line.
   iii. Flexible AC Transmission line.
   iv. New trends in wireless transmission of electrical power.

d. Collect information on:

   i. A.C Distribution System adjacent to your institute.

   ii. Draw a layout diagram of 11KV/400Vsubstation in your campus/adjacent substation.

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry-oriented CO associated with the abovementioned competency:

CO 1 : Interpret the normal operation of the electric transmission and distribution systems.

CO 2 : Maintain the functioning of the medium and high voltage transmission system.

CO 3 : Interpret the parameter soft he extra high voltage transmission system.

CO 4 : Maintain the functioning of the low voltage AC distribution system.

CO 5 : Maintain the components of the transmission and distribution lines.

CO PO MAPPING:

Course code.CO number	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2
C2020410.1	Interpret the normal operation of the electric transmission and distribution systems	3	3	-	2	1	1	2	1	-
C2020410.2	Maintain the functioning of the medium and high voltage transmission system.	3	3	-	2	1	1	2	1	-
C2020410.3	Interpret the parameters of the extra high voltage transmission system.	3	3	-	2	1	1	2	1	-
C2020410.4	Maintain the functioning of the low voltage AC distribution system.	3	3	-	2	1	1	2	1	-
C2020410.5	Maintain the components of the transmission and distribution lines.	3	3	-	2	1	1	2	1	-
C2020410 (Average)		3	3	-	2	1	1	2	1	-

Enter correlation levels 1, 2 or 3 as :
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation, Then put "-"

SOLAR POWER TECHNOLOGIES (TW)
(ELECTRICAL ENGINEERING GROUP)

Subject Code	Term Work						Credits
2020411	No. of Periods Per Week			Full Marks	:	25	01
	L	T	P	Internal (PA)	:	07	
	—	—	02	External (ESE)	:	18	

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Maintain the efficient operation of various types of solar power technologies

Practicals:

1. Dismantle solar power heaters
2. Assemble solar power heaters
3. Assemble the parabolic dish CSP plant.
4. Dismantle the parabolic dish CSP plant.
5. Troubleshoot a CSP plant
6. Assemble the solar PV system.
7. Dismantle the solar PV system
8. Troubleshoot a solar PV system
9. Troubleshoot a solar PV panels and arrays
10. Troubleshoot solar inverters
11. Troubleshoot solar signal conditioners
12. Troubleshoot solar PV MPPT systems
13. Troubleshoot solar off-grid systems
14. Trouble shoot solar net metering systems
15. Troubleshoot solar-wind hybrid systems.

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented Cos associated with the above mentioned competency:

CO 1 : Maintain the solar non-electric equipment.

CO 2 : Maintain CSP plants

CO 3 : Maintain solar PV systems.

CO 4 : Maintain solar PV electronics and MPPT systems

CO 5 : Maintain off-grid and on-grid solar power plants.

CO PO MAPPING:

Course code.CO number	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2
C2020411.1	Maintain the solar non-electric equipment.	3	3	-	2	3	1	2	1	-
C2020411.2	Maintain CSP plants	3	3	-	2	3	1	2	1	-
C2020411.3	Maintain solar PV systems.	3	3	-	2	3	1	2	1	-
C2020411.4	Maintain solar PV electronics and MPPT systems	3	3	-	2	3	1	2	1	-
C2020411.5	Maintain off-grid and on-grid solar power plants.	3	3	-	2	3	1	2	1	-
C2020411 (Average)		3	3	-	2	3	1	2	1	-

Enter correlation levels 1, 2 or 3 as :
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation, Then put "-"

AUTOCAD IN ELECTRICAL ENGINEERING TERMWORK
(ELECTRICAL ENGINEERING GROUP)

Subject Code 2020412	Term Work						Credits
	No. of Periods Per Week			Full Marks	:	25	02
	L	T	P	Internal (PA)	:	07	
	—	—	04	External (ESE)	:	18	

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

1. Basics of Auto CAD
2. Getting comfortable with the Auto CAD Environment
3. Electrical drawings and diagrams IEC Standards & Abbreviations – IS
4. Electrical, power and lighting system plans
5. Design and drawings of Lighting System
6. Design and drawings of Residential electrical plan
7. Design and drawings of Commercial electrical plan
8. Design and drawings of Power System
9. Design and drawings of Power Distribution System
10. Circuit panels and Boards
11. Electrical schematic drawing
12. Electrical panel schedules
13. Electrical one-line diagrams
14. Layouts for lighting showing lighting fixture, emergency lighting etc.

Course Outcome :-Student should able to

CO 1 : Understand basic electrical symbols & their applications.

CO 2 : Implement & Explore Auto CAD Electrical basic & advance commands.

CO 3 : Hands on the exercise of different Power & control drawing.

CO 4 : Creation of drawings, reading & analysis .

CO 5 : Problem solving & decision making skills in complex schemes.

CO PO MAPPING:

Course code.CO number	CO Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2
C2020412.1	Maintain the solar non-electric equipment.	3	3	-	2	3	1	2	1	-
C2020412.2	Maintain CSP plants	3	3	-	2	3	1	2	1	-
C2020412.3	Maintain solar PV systems.	3	3	-	2	3	1	2	1	-
C2020412.4	Maintain solar PV electronics and MPPT systems	3	3	-	2	3	1	2	1	-
C2020412.5	Maintain off-grid and on-grid solar power plants.	3	3	-	2	3	1	2	1	-
C2020411 (Average)		3	3	-	2	3	1	2	1	-

Enter correlation levels 1, 2 or 3 as :

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) If there is no correlation, Then put “-”

SUMMERER TRAINING / INDUSTRAIL VISITS (TW)
(ELECTRICAL ENGINEERING)

Subject Code 2020413	Term Work						Credits
	No. of Periods Per Week			Full Marks	:	25	02
	L	T	P	Internal (PA)	:	07	
	—	—	04	External (ESE)	:	18	

Industrial Visits

Structured industrial visits be arranged and report of the same should be submitted by the individual student, to form a part of the term work.(**ANY THREE OF THEM**)

The industrial visits may be arranged in the following areas / industries :

1) Visit to Transformer Repair Workshop
2) Visit to Electrical Machine Manufacturing Unit.
3) Visit to Load Dispatch Center
4) Visit to Multi Storied Building.
5) Visit to Industry of Power Electronics Devices
6) Visit to Loco Shade.
7) Visit to L & T LT Switchgear Laboratory
8) Visit to Railway Station to study operation of Signaling system.
9) Visit to Large Industry to study Protection Schemes.
10) Any Industry having Automation for manufacturing Processes.

STATE BOARD OF TECHNICAL EDUCATION,BIHAR

Scheme of Teaching and Examinations for

Vth SEMESTER DIPLOMA IN ELECTRICAL ENGINEERING/ ELECTRICAL & ELECTRONIC ENGINEERING.

(Effective from Session 2020-21 Batch)

THEORY

Sr. No.	SUBJECT	SUBJECTCODE	TEACHING SCHEME: Periods per Week	EXAMINATION-SCHEME: Hours of Exam.	Teacher's Assessm e nt (TA) Marks A	Class Test (CT) Marks B	End Semester Exam. (ESE) Marks C	Total Marks (A+B+C)	Pass Marks ESE	Pass Marks in the Subject	Credits
1.	Microprocessor & Microcontroller	2020501	4	3	**10**	**20**	**70**	100	28	**40**	4
2.	Energy Conservation and Audit	2020502	3	3	**10**	**20**	**70**	100	28	**40**	3
3.	Elective III		3	3	**10**	**20**	**70**	100	28	**40**	3
	Electrical Testing and Commissioning (2020503A)			Electrical Estimating and Costing (2020503B)				Switchgear and Protection (2020503C)			
4.	Elective IV		3	3	**10**	**20**	**70**	100	28	**40**	3
	Illumination Practices (2020504A)				Industrial Automation & Control (2020504B)				Electric Traction (2020504C)		
5.	Open Elective I / COE		2	3	**10**	**20**	**70**	100	28	**40**	2
	Soft Computing Techniques (2020505A)										
	Artificial Intelligence (Basics) (2000505B)	Internet of Things (Basics) (2000505C)			Drone Technology (Basics) (2000505D)			3D Printing (Basics) (2000505E)			
	Industrial Automation (Basics) (2000505F)				Electric Vehicles (Basics) (2000505G)			Robotics (Basics) (2000505H)			
	Total :-		15				**350**	500			15

PRACTICAL

Sr. No.	SUBJECT	SUBJECT CODE	TEACHING SCHEME: Periods per Week	EXAMINATION-SCHEME: Hours of Exam.	Practical (ESE): Internal (PA)	Practical (ESE): External (ESE)	Total Marks	Pass Marks in the Subject	Credits
6.	Microcontroller Applications Laboratory	2020506	04 50% physical 50% Virtual	3	15	35	50	20	2
7.	Energy Conservation and Audit	2020507	02 50% physical 50% Virtual	3	07	18	25	10	1
8.	Elective Lab / COE Lab		04 50% physical 50% Virtual	3	20	30	50	20	2
	Electrical Testing and Commissioning Laboratory (2020508A)			Electrical Estimation and Costing Laboratory (2020508B)			Switchgear and Protection Laboratory (2020508C)		
	Artificial Intelligence Lab (Basics) (2000508 B)	Internet of Things Lab (Basics) (2000508 C)		Drone Technology Lab (Basics) (2000508D)			3D Printing & Design Lab (Basics) (2000508E)		
	Industrial Automation Lab (Basics) (2000508F)			Electric Vehicles Lab (Basics) (2000508G)			Robotics Lab (Basics) (2000508H)		
9.	Elective IV Laboratory		02 50% physical 50% Virtual	3	07	18	25	10	1
	Illumination Practices Laboratory (2020509A)			Industrial Automation and Control Laboratory (2020509B)			Electric Traction Lab. (2020509C)		
	Total -		12				150		06

TERM WORK

Sr. No.	SUBJECT	SUBJECT CODE	TEACHING SCHEME: Periods per Week	EXAMINATION-SCHEME: Marks of Internal (PA)	Marks of External (ESE)	Total Marks	Pass Marks in the Subject	Credits
10.	Minor Project	2020510	04	**15**	35	50	**20**	2
11.	Term Work		02	**20**	30	50	**20**	1
	Course under Moocs/ NPTEL / Others (2020511)	Artificial Intelligence (Basics) (TW) (2000511 B)			Internet of Things (Basics) (TW) (2000511 C)		Drone Technology (Basics) (TW) (2000511D)	
	3D Printing (Basics) (TW) (2000511E)	Industrial Automation (Basics) (TW) (2000511F)			Electric Vehicles (Basics) (TW) (2000511G)		Robotics (Basics) (TW) (2000511H)	
	Total:-		06			100		03
Total Periods per week Each of duration One Hour 33					Total Marks = **750**			**24**

MICROPROCESSOR & MICROCONTROLLER
(ELECTRICAL ENGINEERING GROUP)

No. of Period in One Session 60

SubjectCode	Theory						Credits
2020501	No. of Periods Per Week			FullMarks	:	100	04
	L	T	P/S	ESE	:	70	
	04	—	—	TA	:	10	
	—	—	—	CT	:	20	

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- To introduce students with the architecture and operation of typical microprocessors and microcontrollers.
- To familiarize the students with the programming and interfacing of microprocessors and microcontrollers.
- To provide strong foundation for designing real world applications using microprocessors and microcontrollers.
- Maintain different types of microcontroller-based systems.

CONTENTS: THEORY

Unit	Name of Topics	Hrs
Unit-I	**Microprocessor 8085** Evolution of microprocessors, Architecture of 8085, Pin diagram, Control signals, Multiplexing of address & Data Bus **8085 Assembly Language Programming** Programming Model of 8085, Addressing Modes Instruction classification, Instruction format, Instruction set Stacks & subroutines Assembly Language programming	12
Unit-II	**Introduction to Microcontrollers** Evolution of Microcontrollers Block diagram of Microcomputer, elements of Microcomputer, types of buses Von Neuman and Harward Architecture, Compare Microprocessor and Microcontrollers, Need of Microcontroller, Family of Microcontrollers and their specifications Versions of Microcontroller 8951, 89C1051, 89C2051, 89C4051 with their specifications and comparison	14
Unit-III	**Architecture of Microcontroller 8051** Block diagram of 8051, function of each block Pin diagram, function of each pin, Concept of Internal memory and External memory (RAM and ROM) Internal RAM structure, Reset and clock circuit, Various registers and SFRs of 8051	14
Unit-IV	**8051 Instruction Set and Programs** Overview of 8051 instruction set Various addressingmodes Classification of instructions Data transfer instructions Arithmetic instructions Logical instructions Branching instructions Bit manipulation instructions Stack, subroutine and interrupt related instructions Programs based on above instructions.	10
Unit-V	**8051 Internal Peripherals and Related Programs** I/O ports- List, diagram, read write operation, instructions and related SFRs Timers/counters – list, related SFRs, programming modes, operations with diagram. Serial communication- Basics of serial communication, baud rate, related SFRs, programming modes, operations with diagram. Interrupts- related SFRs, types, operations with diagram. Power saving operation- modes, related SFR.	10
	Total	**60**

References:

1. Kenneth, Ayala, 8051 Microcontroller Architecture Programming and Application, PHI Learning, New Delhi,ISBN:978-1401861582
2. Mazidi,MohmadAli;Mazidi,JaniceGelispe;MckinlayRolineD.,The8051Microcontrollerand Embedded system, Pearson Education, Delhi, ISBN978-8177589030
3. Pal, Ajit, Microcontroller Principle and Application, PHI Learning, New Delhi, ISBN13: 978-81-203- 4392-4
4. Deshmukh, Ajay, Microcontroller Theory and Application, McGraw Hill., New Delhi, ISBN- 9780070585959
5. Kamal, Raj, Microcontroller Architecture Programming, Interfacing and System Design, Pearson Education India, Delhi, ISBN:9788131759905
6. Mathur; Panda, Microprocessors and Microcontrollers, PHI Learning, New Delhi, ISBN:978-81- 203-5231-5
7. Krishna Kant, Microprocessors and Microcontrollers: Architecture programming and System Design, PHI Learning, New Delhi,ISBN:978-81-203-4853-0
8. Microprocessor Architecture, Programming, and Applications with the 8085, Ramesh Gaonkar, Penram International Publishing (India) Pvt. Ltd.
9. Manoranjan Kumar , Microprocessor & Applications , FPH
10. Sanjeev Gupta , Microprocessor & Microcontroller , FPH

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

CO 1 : Interpret the salient features of various types of microcontrollers.
CO 2 : Interpret the salient features of archetype of types microcontrollers IC8051
CO 3 : Maintain the program features of the Microcontroller basedapplication
CO 4 : Develop assembly languageprogram
CO 5 : Develop programs to interface 8051 microcontrollers with LED/SWITCH

ENERGY CONSERVATION AND AUDIT
(ELECTRICAL ENGINEERING GROUP)

No. of Period in One Session 45

SubjectCode	Theory						Credits
2020502	No. of Periods Per Week			FullMarks	:	100	03
	L	T	P/S	ESE	:	70	
	03		—	TA	:	10	
	—	—	—	CT	:	20	

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- To facilitate the students to achieve a clear conceptual understanding of technical and commercial aspects of energy conservation and energy auditing.
- To enable the students to develop managerial skills to assess feasibility of alternative approaches and drive strategies regarding energy conservation and energy auditing.

CONTENTS: THEORY

Unit	Name of Topics	Hrs
Unit-I	**Energy Conservation Basics** Energy Scenario: Primary and Secondary Energy, Energy demand and supply, National scenario. Energy conservation and Energy audit; concepts and difference Indian Electricity Act 2001; relevant clauses of energy conservation BEE and its Roles, MEDA and its Roles, Star Labelling: Need and its benefits.	**04**
Unit-II	**Energy Conservation in Electrical Machines** Need for energy conservation in induction motor and transformer, Energy conservation techniques in induction motor by: Improving Power quality. Motor survey Matching motor with loading. Minimizing the idle and redundant running of motor, Operating in star mode. Rewinding of motor. Replacement by energy efficient motor, Periodic maintenance Energy conservation techniques in Transformer. Load sharing, Parallel operation, Isolating techniques. Replacement by energy efficient transformers, Periodic maintenance, Energy Conservation Equipment: Soft starters, Automatic star delta convertor, Variable Frequency Drives, Automatic p. f. controller (APFC), Intelligent p. f. controller (IPFC) Energy efficient motor; significant features, advantages, applications and limitations. Energy efficient transformers, amorphous transformers; epoxy Resin cast transformer / Dry type of transformer.	**12**
Unit-III	**Energy conservation in Electrical Installation systems** Aggregated Technical and commercial losses (ATC); Power system at state, regional, national and global level. Technical losses; causes and measures to reduce by. a) Controlling I & R losses. b) Optimizing distribution voltage c) Balancing phase currents d) Compensating reactive power flow Commercial losses: causes and remedies Energy conservation equipment: Maximum Demand Controller , kVAR Controller, Automatic Power factor controller(APFC) Energy Conservation in Lighting System a) Replacing Lamp sources. b) Using energy efficient luminaries.	**12**

	c) Using light controlled gears. d) Installation of separate transformer / servo stabilizer for lighting. e) Periodic survey and adequate maintenance programs. Energy Conservation techniques in fans, electronic regulators.	
Unit-IV	**Energy conservation through Cogeneration and Tariff** Co-generation and Tariff; concept, significance for energy conservation Co-generation Types of cogenerations on the basis of sequence of energy use (Topping cycle, Bottoming cycle) Types of cogeneration basis of technology (Steam turbine cogeneration, Gas turbine cogeneration, Reciprocating engine cogeneration). Factors governing the selection of cogeneration system. Advantages of cogeneration. Tariff: Types of tariff structure: Special tariffs; Time-off-day tariff, Peak-off- day tariff,Power factor tariff, Maximum Demand tariff, Load factor tariff. Application of tariff system to reduce energy bill.	**10**
Unit-V	**Energy Audit of Electrical System** Energy audit (definition as per Energy Conservation Act) Energy audit instruments and their use. Questionnaire for energy audit projects. Energy flow diagram (Sankey diagram) Simple payback period, Energy Audit procedure (walk through audit and detailed audit). Energy Audit report format.	**7**
	Total	**45**

References:

1. Guide Books No. 1 and 3 for National Certification Examination for Energy Managers and Energy Auditors,
2. Bureau of Energy Efficiency (BEE), Bureau of Energy Efficiency (A Statutory bodyunder Ministry of Power, Government of India) (Fourth Edition2015).
3. Energy Technology by O.P. Gupta, , Khanna Publishing House, NewDelhi
4. India - The Energy Sector, by Henderson, P. D., University Press, Delhi, 2016. ISBN: 978- 0195606539
5. Energy Management Handbook by W. Turner,Fairmount Press, 2012, ISBN9781304520708
6. Energy Management and Conservation, by , K. SharmaV., Venkataseshaiah; I K International Publishing House Pvt. Ltd; 2011 ISBN9789381141298
7. Principles of Power System, by V.K. Mehta , S. Chand &Co.New Delhi, 2016, ISBN9788121905947
8. Energy Management by Sanjeev; Singh, Umesh Rathore,S K Kataria&Sons,New Delhi ISBN-13: 9789350141014.
9. Efficient Use and Management of Electricity in Industry, by Desai, B. G.; Rana, J. S.; A. Dinesh, V.; Paraman, R., Devki Energy Consultancy Pvt.Ltd.
10. Energy Engineering And Management by Aman Chakrabarti, , e-books Kindle Edition
11. Energy Conservation and Audit ,R.K. Sahney , FPH

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

CO 1 : Interpret energy conservation policies inIndia.

CO 2 : Implement energy conservation techniques in electrical machines.

CO 3 : Apply energy conservation techniques in electrical installations.

CO 4 : Use Co-generation and relevant tariff for reducing losses.

CO 5 : Undertake energy audit for electrical system.

Elective III
ELECTRICAL TESTING AND COMMISIONING
(ELECTRICAL ENGINEERING GROUP)

Subject Code	Theory						Credits
2020503A	No. of Periods Per Week			FullMarks	:	100	03
	L	T	P/S	ESE	:	70	
	03		—	TA	:	10	
	—	—	—	CT	:	20	

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Understand the need for a robust commissioning and testing.
- Develop a methodology for fault finding in new and existing systems
- Improve your knowledge of commissioning and testing protection systems
- Follow standard safety procedures in testing and commissioning of electrical equipment.

CONTENTS: THEORY

Unit	Name of Topics	Hrs
Unit-I	**Electrical Safety and Insulation** Do's and don'ts regarding safety in domestic electrical appliances as well for substation/ power station operators Electrical safety in industry/power stations/ substations at the time of operation/ control/ maintenance. Fire detection alarm, fire-fighting equipment Factors affecting life of insulating materials, classifications of insulating materials as per IS:1271-1958 Measuring insulation resistance by different methods such as i) Polarization, ii) Dielectric absorption, iii) Megger and to predict the condition of insulation Reconditioning of insulation, Insulating oil - properties of insulating oil, causes of deterioration ofoil, testing of transformer oil as per IS 1866-1961	**10**
Unit-II	**Installation and Erection** Concept of foundation for installation of machinery, Requirements of foundation for static and rotating electrical machinery. Concept of leveling and aligning, Procedure for leveling and aligning, alignment of direct coupled drive, effects of misalignment Installation of transformer as per I.S.-1886-1967 and procedure of installation of transformer, Requirements of installation of pole mounted transformer Requirements of installation of rotating electrical machines as per I.S. 900 - 1965 Devices and tools required for loading, unloading, lifting, and carrying heavy equipment and precautions to be taken while handling them.	**10**
Unit-III	**Testing and Commissioning** Concept of testing, Objectives of testing. Roles of I.S.S. in testing of electrical equipment, Types of tests and concepts, Routine tests, type tests, supplementary test, special tests, Methods of testing - Direct/Indirect/Regenerative testing. Tolerances for the various items for equipment –transformer, induction motor, dc motor, synchronous machines Commissioning, Tests before Commissioning for transformer, induction motor, alternator Testing of transformer as per I.S.1886- 1967 and I.S.2026- 1962 Testing of three-phase Induction motor as per I.S.325 - 1970. Testing of single-phase induction motor as per I.S.990-1965. Testing of synchronous machines as per ISS Testing of D.C. machines	**10**

Unit-IV	**Troubleshooting Plans** Internal and external causes for failure / abnormal operation of equipment. List of mechanical faults, electrical faults and magnetic faults in the electrical equipment remedies, applications Use of tools like bearing puller, filler gauges, dial indicator, spirit level, megger, earth tester, and growler. Common troubles in electrical equipments and machines. Preparation of trouble shooting charts for D.C. Machines, AC Machines and transformers.	**06**
Unit-V	**Maintenance** Concept of maintenance, types of maintenance, Routine, preventive and breakdown maintenance. Causes of failure of electrical machines Preventive maintenance-procedure or developing maintenance schedules for electrical machines. Factors affecting preventive maintenance schedules, Concept of TPM, Pillars of TPM, Identification of different types of faults developed such as mechanical/ electrical/ magnetic faults Maintenance schedules of the following as per I.S.S. a) Distribution transformer as perI.S.1886-1967 b) Single phase and three phase Induction motors as per I.S.900- 1965. c) Batteries	**09**
	Total	**45**

References:

1. Design and Testing of Electrical Machines ISBN No 8120336453,9788120336452. By Deshpande.
2. Operation and Maintenance of Electrical Equipment Vol-I, ISBN No8185099022 B V Rao, S Asia Club House, First Reprint, 2011,
3. Maintenance and Repairs, ISBN No 9780071396035 by Rosenberg. Mc GRAW-HILL, 1st Edition, May 2003,
4. Preventive Maintenance of Electrical Apparatus, ISBN No 10: 007030839X 13:978-0070308398 by S.K.Sharotri, Glencoe/ McGraw- Hill; 2nd Edition, June 1969;
5. Electrical Testing and Commissioning , Manoj Jaiswal , FPH

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

CO 1 : Follow safety procedures with respect to earthing and insulation of electrical equipment

CO 2 : Select proper tools, equipment, for installation, testing, maintenance of electrical machines and transformers.

CO 3 : Test and commission electrical equipment in accordance with IS codes

CO 4 : Make plans for trouble shooting electrical machines.

CO 5 : Undertake regular preventive and break down maintenance.

****

Elective III

ELECTRICAL ESTIMATING AND COSTING

(ELECTRICAL ENGINEERING GROUP)

Subject Code 2020503B	Theory						Credits
	No. of Periods Per Week			FullMarks	:	100	03
	L	T	P/S	ESE	:	70	
	03		—	TA	:	10	
	—	—	—	CT	:	20	

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Design electrical installation with costing fortendering

CONTENTS: THEORY

Unit	Name of Topics	Hrs
Unit-I	Electric Installation and Safety Scope and features of National electric code 2011 Types of electrical installation Fundamental principles for electrical installation Permit to work, safety instructions and safety practices Purpose of estimating and costing.	**07**
Unit-II	Estimation and Costing Meaning and purpose of- Rough estimate, detailed estimate, supplementary estimate, annual maintenance estimate and revised estimate Factors to be considered while preparation of detailed estimate and economical execution of work Contracts- Concepts of contracts, types of contracts, contractor, role of contractor Tenders and Quotations- Type of tender, tender notice, preparation of tender document, and method of opening of tender Quotation, quotation format, comparison between tender and quotation Comparative statement, format comparative statement. Order format, placing of purchasing order. Principles of execution of works, planning, organizing and completion of work, Billing of work	**08**
Unit-III	Non-Industrial Installations Types of Non-industrial installations-- Office buildings, shopping and commercial centre, residential installation, Electric service and supply Design consideration of electrical installation in commercial buildings. Design procedure of installation- steps involved in detail, Estimating and costing of unit Earthing of commercial installation. Design electrical installation scheme of commercial complex. Erection, Inspection and testing of installation as per NEC	**10**
Unit-IV	Industrial Installation Classification of industrial buildings Classification based on power consumption. Drawing of wiring diagram and single line diagram for single phase and three phase Motors. Design consideration in industrial installations Design procedure of installation-detailed steps Design electrical installation scheme of factory/ small industrial unit, Preparation of material schedule and detailed estimation Installation and estimation of agricultural pump and flour mill.	**10**
Unit-V	Public Lighting Installation Classification of outdoor installations streetlight/ public lighting installation Street light pole structures. Selection of equipment, sources used in street light installations. Cables, recommended types and sizes of cable. Control of street light installation.	**06**

	Design, estimation and costing of streetlight Preparation of tenders and abstracts.	
Unit-VI	Distribution Lines and LT Substation Introduction to overhead and underground distribution line, Materials used for distribution line HT and LT Cables used for distribution line, factors determining selection of LT/ HT power Cables, cable laying and cable termination method according to IS Design, estimation and costing of HT / LT overhead line and underground cable. Types of 11 KV Distribution substations their line diagram, Estimation of load, Load factor, diversity factor and determination of rating of distribution. Transformer, Design, estimation and costing of outdoor and indoor 11 KV substations.	**04**
	Total	**45**

References:

1. Electrical Design Estimating and Costing, by K.B. Raina, and S.K. Bhattacharya New Age Interna- tional Ltd., New Delhi, ISBN978-81-224-0363-3
2. Electrical Estimating and Costing, New Delhi, ISBN-13: 9780074624784 by N. Allagappan,S.Ekambarram,
3. Electrical Estimating and Costing by Surjit Singh,Dhan pat Rai and Co. New Delhi, ISBN: 1234567150995
4. A Course in Electrical Installation Estimating and Costing by J.B.Gupta, S K Kataria and Sons, New Delhi,ISBN:978-93-5014-279-0
5. Code of practice for electrical wiring installation Bureau of Indian Standard, IS: 732-1989,
6. Bureau of Indian Standard, SP 30 National Electrical Code2010
7. Bureau of Indian Standard, SP 72 National Lighting Codes2010
8. Electrical Estimating & Costing ,Savinder Singh , Foundation Publishing House.
9. Electrical Estimating & Contracting , Subodh Prakash , Foundation Publishing House.

<u>Course outcomes:</u>

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

CO 1 : Follow National Electrical Code 2011 in electrical installations.

CO 2 : Estimate the electrical installationworks

CO 3 : Estimate the work of non-industrial electrical installations.

CO 4 : Estimate the work of industrial electrical installations.

CO 5 : Prepare abstract, tender, quotation of public lighting and other installations.

CO 6 : Prepare abstract, tender, quotation of low tension (LT) substations.

****

Elective III

SWITCHGEAR AND PROTECTION

(ELECTRICAL ENGINEERING GROUP)

Subject Code	Theory						Credits
2020503 C	No. of Periods Per Week			FullMarks	:	100	03
	L	T	P/S	ESE	:	70	
	03		—	TA	:	10	
	—	—	—	CT	:	20	

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- To understand the need of protection of electric equipment and their protection schemes.
- To understand operations & characteristics of various electromagnetic and static relays.
- To understand the operations of various types of circuit breakers and their ratings.
- To understand the unit protection and over voltage protection of different apparatus in power system.
- Maintain switchgear and protection schemes used in electrical powersystems.

CONTENTS: THEORY

Unit	Name of Topics	Hrs
Unit-I	Basics of Protection Necessity, functions of protective system. Normal and abnormal conditions. Types of faults and their causes. Protection zones and backup protection Symmetrical & Asymmetrical fault calculations in lines fed by generators through Transformers, Need of current limiting reactors and their arrangements.	**06**
Unit-II	Circuit Interruption Devices Isolators- Vertical break, Horizontal break and Pantograph type. HRC fuses – Construction, working, characteristics and applications. Arc formation process, methods of arc extinction (High resistance and Low resistance), Arc voltage, Recovery voltage, Re-striking voltage, RRRV. -Working, construction, specifications and applications of: Sulphur-hexa Fluoride (SF6), Vacuum circuit breaker, Air circuit breakers (ACB) Miniature circuit breakers (MCB), Moulded case circuit breakers (MCCB) Selection of LT and HT circuit breakers (ratings), Selection of MCCB for Motors, Gas insulated switchgear.	**12**
Unit-III	Protective Relays Fundamental quality requirements: Selectivity, Speed, Sensitivity, Reliability, Simplicity,Economy. Basic relay terminology- Protective relay, Relay time, Pick up, Reset current, current setting, Plug setting multiplier, Time setting multiplier. Protective relays: Classification, principle of working, construction and operation of – Electromagnetic (Attracted armature type, Solenoid type, Watt-hour meter type) relay, Thermal relay. Block diagram and working of Static relay. Overcurrent relay-Time current characteristics. Microprocessor based over current relays: Block diagram, working. Distance relaying- Principle, operation of Definite distance relays. Directional relay: Need and operation. Operation of current and voltage differential relay.	**12**
Unit-IV	Protection of Alternator and Transformer Faults, Differential protection, Over current, earth fault, over heating and field failure, protection. Reverse power protection. Transformer Protection Limitations of differential protection. Buchholz relay: Construction, operation, merits and demerits.	**10**

Unit-V	Protection of Motors, Bus-bar and Transmission Line. Short circuit protection, Overload protection, Faults on Bus bar and Transmission Lines. Over current, Distance and Pilot wire protection, Transmission line.	**05**
	Total	**45**

References:

1. Principles of Power System V. K Mehta Rohit Mehta, S. Chandand Co., New Delhi., ISBN: 978-81-2192-496-2.
2. Switchgear and Protection by Sunil Rao. Khanna Publishers, New Delhi, ISBN: 978-81-7409- 232-3.
3. Switchgear and Power System Protection, by R.P. Singh, PHI Learning, New Delhi, ISBN: 978- 81-203-3660-5.
4. Switchgear and Protection by J.B.Gupta.S. K. Kataria and Sons, New Delhi, ISBN: 978-93-5014-372-8.
5. S. R., Switchgear and Protection by Veerappan, N., Krishnamurthy, , S .Chand and Co., New Delhi. ISBN:978-81-2193-212-7.
6. Power System Protection and Switchgear by Ram, Badri; Vishwakarma D. McGraw-Hill, New Delhi. ISBN: 978-07-107774-X
7. Prabhat Kumar , Switchgear and Protection , FPH
8. Switchgear Protection , Rahul Gupta ,FPH

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are tobe taught and implemented, so that the student demonstrates the following industry-oriented COs associated with the above-mentioned competency:

CO 1 : Identify various types of faults in power system.

CO 2 : Select suitable switchgears for different applications.

CO 3 : Test the performance of different protective relays.

CO 4 : Maintain protection systems of alternators and transformers.

CO 5 : Maintain protection schemes for motors and transmission lines.

CO 6 : Maintain protection schemes for power system against over voltages.

****

Elective IV

ILLUMINATION PRACTICES

(ELECTRICAL ENGINEERING GROUP)

Subject Code 2020504A	Theory						Credits
	No. of Periods Per Week			FullMarks	:	100	03
	L	T	P/S	ESE	:	70	
	03	—	—	TA	:	10	
	—	—	—	CT	:	20	

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- To provide an introduction to the fundamentals of illumination engineering and architectural lighting design.
- To impart lighting fundamentals, measurement, and technology and their application in the analysis and design of architectural lighting systems
- Design illumination schemes and associated electrification of buildings.

CONTENTS: THEORY

Unit	Name of Topics	Hrs
Unit-I	Fundamentals of illumination Basic illumination, Terminology, Laws of illumination Polar curves, polar curve: its meaning and applications for designing the lamp. Concept of Photometry, Measurement ofillumination Lighting calculation methods, two watt maker method, Lumens or light flux method, Point to point method Standards for illumination	**08**
Unit-II	Types of lamps Incandescent lamp, ARC lamps – AC and DC arc lamps, Fluorescent lamp Types of other lamps: Mercury vapour lamp, HPMV lamp, Mercury iodide lamp, Sodium vapour lamp, Halogen Lamps, Ultraviolet Lamps, Neon Lamps. Neon Sign Tubes. Metal halides, HID and Arc lamps LED lamps, CFL, Lasers Selection Criteria for lamps	**08**
Unit-III	Illumination Control and Control Circuits Purpose of lighting control, and Dimmer, Resistance type Salt water Dimmer Working principle and operation of Dimmer Transformer and their types, Dimmer Transformer, Auto transformer dimmer, Two winding transformer dimmer Electronic Dimmer: working principle and operation a. Thyristor operated dimmer b. Triac operated dimmer Control of Enhance Lighting, Methods used for light control, Control circuits for lamps (re- fer): ON/OFFcontrol Control circuits for lamps: single lamp controlled by single switch, two switches. Single Lamp control by two point method, three point method and four point method,	**12**
Unit-IV	Illumination for Interior Applications Standard for various locations of Interior Illumination Design considerations for Interior location of residences (1/2/3/4 BHK), Commercial, Industrial premises Illumination scheme for different Interior locations of Residential, Commercial, industrial unit	**10**

Unit-V	Illumination for Interior Applications Factory Lighting Street Lighting (Latest Technology), Flood Lighting, Railway Lighting, Lighting for advertisement /Hoardings/sports lighting, Agriculture and Horticulture lighting, Health Care Centers / Hospitals, Decorating Purposes, Stage Lighting, Aquariums and Ship-yards Special purpose lamps used in photography video films.	**07**
	Total	**45**

References:

1. Applied Illumination Engineering, by L. jack Lindsey, The Fairmont PressInc.
2. Simons, R. H., Bean, Robert; Lighting Engineering: Applied Calculations, Architectural Press. ISBN:0750650516.
3. Handbook of Applied Photometry, by M Decusatis Casimer, Springer, ISBN1563964163.
4. Butterworths, Lyons Stanley, Handbook of Industrial Lighting,Butterworths
5. Lighting Control Technology and Applications by S RobertSimpson, , FocalPress
6. Energy Management in Illuminating Systems, by Kao Chen CRCPress,
7. Sanjeev Handa , Illumination Practices , FPH

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry-oriented COs associated with the above-mentioned competency:

CO 1 : Select relevant lamps for various applications considering illumination levels

CO 2 : Select the lighting accessories required for selected wiring scheme.

CO 3 : Design relevant illumination schemes for interior applications.

CO 4 : Design Illumination schemes for various applications

CO 5 : Design Illumination schemes for various outdoor applications.

****

INDUSTRIAL AUTOMATION AND CONTROL
(ELECTRICAL ENGINEERING GROUP)

Subject Code	Theory						Credits
2020504 B	No. of Periods Per Week			Full Marks	:	100	03
	L	T	P/S	ESE	:	70	
	03	—	—	TA	:	10	
	—	—	—	CT	:	20	

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Understand the working principle and applications of PLC program for Maintain Industrial Automation Systems
- Develop PLC program and appreciate importance of SCADA in DCS in industrial applications.

CONTENTS: THEORY

Chapter	Name of the Topic	Hours
Unit-01	**Introduction to Industrial Automation** Automation: Need and benefits. Types of automation system: Fixed, Programmable, Flexible Different systems used for Industrial automation: PLC, HMI, SCADA, DCS, Drives. Evolution of PLC	05
Unit-02	**PLC Fundamentals** Building block soft PLC: CPU, Memory organization, Input- outputmodules(discreteand analog), Specialty I/O Modules, Power supply Fixed and Modular PLC and their types, Redundancy in PLC module I/O module selection criteria.Interfacing different I/O devices with appropriate I/O modules	06
Unit-03	**PLC Programming and Applications** PLC I/O addressing PLC programming Instructions: Relay type instructions, Timer instructions: On delay, off de- lay, retentive, Counter instructions: Up, Down, High speed, Logical instructions, Comparison Instructions, Data handling Instructions, Arithmetic instructions. PLC programming language: Functional Block Diagram (FBD), Instruction List. Structured text, Sequential Function Chart (SFC), Ladder Programming. Simple Programming examples using ladder logic: Language based on relay, timer counter, logical, comparison, arithmetic and data handling instructions. PLC Based Applications: Motor sequence control, Traffic light control, Elevator control, Tank Level control, Conveyor system, Stepper motor control, Reactor Control Gate trigger circuits – Resistance and Resistance-Capacitance circuits	12
Unit-04	**Control System** Concept of control system, Types of control system,Transfer function , Basic block diagram of control system, Block diagram reduction Techniques., Applications of control system Fundamentals of time domain and frequency analysis of second order system (Specification parameters only) P, I,D, P+I, P+D, P+I+D actions, Potentiometer- working uses as error detector, Servo motors - AC & DC working Principle. Synchros- Transmitter & control transformer Tacho generator- working Principle Stepper motor (Permanent magnet & Variable reluctance)-working Principle	14
Unit-05	**Supervisory Control and Data Acquisition System (SCADA)** Introduction to SCADA: Typical SCADA architecture/block diagram, Benefits of SCADA Various editors of SCADA Interfacing SCADA system with PLC: Typical connection diagram, Object Linking & embed- ding for Process Control (OPC) architecture, Steps in Creating SCADA Screen for simple object, Steps for Linking SCADA object (defining Tags and Items) with PLC ladder program using OPC. Applications of SCADA: Traffic light control, water distribution, pipeline control	08
	Total	45

References:

1. Dunning, G., Introductionto Programmable Logic Controllers, Thomson/Delmarlearning, New Delhi, 2005,ISBN 13 : 9781401884260
2. Jadhav, V. R., Programmable Logic Controller, Khanna publishers, New Delhi, 2017, ISBN : 9788174092281
3. Petruzella, F.D., Programmable Logic Controllers, McGraw Hill India, New Delhi, 2010, ISBN: 9780071067386
4. Hackworth, John; Hackworth, Federic, Programmable Logic Controllers, PHI Learning, New Del- hi, 2003, ISBN : 9780130607188
5. Stenerson Jon, Industrial automation and Process control, PHI Learning, New Delhi, 2003, ISBN : 9780130618900
6. Mitra, Madhuchandra; Sengupta, Samarjit, Programmable Logic Controllers and Industrial Automation - An introduction, Penram International Publication, 2015, ISBN: 9788187972174
7. Boyar, S. A., Supervisory Control and Data Acquisition, ISA Publication, USA, ISBN: 978- 1936007097
8. Bailey David; Wright Edwin, Practical SCADAforindustry, Newnes(animprint of Elsevier), UK 2003, ISBN:0750658053

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry-oriented Cos associated with the above-mentioned competency:

CO 1 : Identify different types of automation systems.

CO 2 : Interface I/O devices with the PLC modules.

CO 3 : Develop PLC ladder programs for various applications.

CO 4 : Select the suitable motor drives for different applications

2. Prepare simple SCADA applications

****

Elective IV

ELECTRIC TRACTION

(ELECTRICAL ENGINEERING GROUP)

Subject Code	Theory						Credits
2020504C	No. of Periods Per Week			FullMarks	:	100	03
	L	T	P/S	ESE	:	70	
	03	—	—	TA	:	10	
	—	—	—	CT	:	20	

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Maintain electric tractionsystems.
- Understand different traction systems and latest trends in traction systems.
- Differentiate services of traction system based on speed time curve.
- Understand the Control of different types of traction motors

CONTENTS: THEORY

Unit	Name of Topics	Hrs
Unit-I	Basics of Traction General description of Electrical Traction system in India. Advantages and Disadvantages of Electric Drive, Diesel Electric Drive, Battery Drive Problems associated with AC traction System and remedies for it. Voltage balance, current balance, production of harmonics, induction effects. Metro rail system, features	**06**
Unit-II	Power Supply Arrangements Constituents of supply system: - Substation: layout, list of equipment and their functions, Feeding post: list of equipment and their functions, Feeding and sectioning Arrangements Sectioning and paralleling post Sub sectioning and Paralleling post Sub sectioning post Elementary section Major equipment at substation, Miscellaneous equipment at control post or Switching station Protection system for traction transformer and 25 kV centenary construction	**10**
Unit-III	Overhead Equipment Different types of overhead equipment Pentagonal OHE, Catenary Construction Different Types of Catenary according to speed Limit, OHE Supporting Structure, Catenary assembly diagram Overhead system- Trolley collector, Bow collector, Pantograph Collector Types and construction of pantograph	**10**
Unit-IV	Electric Locomotive Classification and Nomenclature of Electric Locomotive Block diagram of AC locomotive Power Circuit of AC Locomotive Equipment (List andFunction only) used in auxiliary circuit of AC Locomotive, Loco bogie, classification according to wheel arrangements, Maintenance of AC systems	**10**
Unit-V	Traction Motors and Train Lighting Desirable characteristics of traction motor. Types of motors used for traction with their characteristics and features, Control of motors used for traction and methods to control, Requirements of braking, types of braking Electric braking, Regenerative braking Systems of train lighting, Single battery, double battery, parallel block System, SG, HOG, End on generation	**05**

Unit-VI	Signaling and Supervisory Control Requirements of signaling systems Types of signals, track circuits, Advantages of remotecontrol Systems of remote control, equipment andnetwork Metrorail-supply systems, advantages, schemes in India	**04**
	Total	**45**

References:

1. G.C. Garg, Utlization of Electric Power & Electric Traction, Khanna Book Publishing Co., New Delhi (ISBN: 978-93-86173-355) Revised Ed.2018
2. Gupta J.B., S.K.Kataria and Son, Utilization of Electric power andtraction
3. Partab H., Dhanpat Rai and Co,' Art and Science of Utilization of Electrical Energy
4. Partab H., Dhanpat Rai and Co, Modern Electric Traction
5. Suryanarayana N.V., New Age International Publishers, Reprint2010
6. Electric Traction , Deepak Srivastava , FPH
7. Electric Traction , B D Singh , FPH
8. Open Shaw Taylor, Orient Longman ltd., Utilisation of electrical energy.

<u>Course outcomes:</u>

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

CO 1 : Interpret the traction layout and itssystems

CO 2 : Maintain the power supply arrangements.

CO 3 : Maintain the function of the overhead equipment for electrictraction

CO 4 : Maintain the different components of the electric locomotive.

CO 5 : Maintain the traction motor and train lighting system

CO 6 : Maintain the signalling and supervisory control systems.

****

Open Elective I /COE

SOFT COMPUTING TECHNIQUES

(ELECTRICAL ENGINEERING GROUP)

Subject Code	Theory						Credits
2020505A	No. of Periods Per Week			FullMarks	:	100	02
	L	T	P/S	ESE	:	70	
	02	—	—	TA	:	10	
	—	—	—	CT	:	20	

Course Learning Objectives:

- To learn Fuzzy logic and its applications.
- To learn artificial neural networks and its applications.
- To solving single-objective optimization problems using Gas.
- To solving multi-objective optimization problems using Evolutionary algorithms(MOEAs).
- Applications of soft computing to solve problems in varieties of application domains.

CONTENTS: THEORY

Unit	Name of Topics	Hrs./Unit
Unit-I	Problem Solving Methods and Tools: Problem Space, Problem solving, State space. Algorithm's performance and complexity, Search Algorithms, Depth first search method, Breadth first search methods their comparison, A*, AO*, Branch and Bound search techniques, p type, Np complete and Np Hard problems.	08
Unit-II	Evolutionary Computing Methods: Principles of Evolutionary Processes and genetics, A history of Evolutionary computation and introduction to evolutionary algorithms, Genetic algorithms, Evolutionary strategy, Evolutionary programming, Genetic programming. Genetic Algorithm and Genetic Programming: Basic concepts, working principle, procedures of GA, flow chart of GA, Genetic representations, (encoding) Initialization and selection, Genetic operators, Mutation, Generational Cycle, applications.	10
Unit-III	Swarm Optimization: Introduction to Swarm intelligence, Ant colony optimization (ACO), Particle swarm optimization (PSO), Artificial Bee colony algorithm (ABC), Other variants of swarm intelligence algorithms.	08
Unit-IV	Advances in Soft Computing Tools: Fuzzy Logic, Theory and applications, Fuzzy Neural networks, Pattern Recognition, Differential Evolution, Data Mining Concepts, Applications of above algorithms in manufacturing engineering problems. Artificial Neural Networks: Neuron, Nerve structure and synapse, Artificial Neuron and its model, activation functions, Neural network architecture: single layer and multilayer feed forward networks, recurrent networks. Back propagation algorithm, factors affecting back propagation training, applications	12
Unit-V	Application of Soft Computing to Mechanical Engineering/Production Engineering Problems: Application to Inventory control, Scheduling problems, Production, Distribution, Routing, Transportation, Assignment problems	07
	Total	45

References:

1. Tettamanzi Andrea, Tomassini and Marco, Soft Computing Integrating Evolutionary, Neural and Fuzzy Systems, Springer,2001.
2. Elaine Rich, Artificial Intelligence, McGraw Hill, 2/e,1990.
3. Kalyanmoy Deb, Multi-objective Optimization using Evolutionary Algorithms, John Wiley

and Sons, 2001

4. Alok Gupta , Soft computing Techniques , Foundation Publishing House.

.**Course outcomes:**

At the end of the course, the student will be able to:

CO 1 : Apply soft computing techniques for design, control and optimization of Manufacturing systems.

CO 2 : Classify and differentiate problem solving methods andtools.

CO 3 : Apply A*, AO*, Branch and Bound search techniques for problemsolving.

CO 4 : Formulate an optimization problem to solve using evolutionary computing methods.

A) **Course Code** : **2000505B / 2000508B /2000511B**

B) **Course Title** : Artificial Intelligence (Basics)

C) **Pre- requisite Course(s)** :

D) **Rationale** :

Artificial intelligence is the theory and development of computer systems able to perform tasks such as, visual perception, speech recognition, decision-making etc. normally requiring human intelligence. Data analytics gives the basis of developing any artificial intelligence system.

The Python programming language is one of the most accessible programming languages, has several modules to write programs to solve Artificial Intelligence, Machine Learning, Data Analysis problems. Moreover, it has simplified syntax and versatile data structures and functions to speed up the code writing efficiently.

This course provides the basics for Artificial Intelligence problem solving techniques, data analytics and articulates the different dimensions of these areas. This course also provides the students the foundations for data analytics with python. The course explains data science techniques and the various Python programming packages required to prepare data for analysis, perform data analytics and create meaningful data visualization.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/laboratory/workshop/field/ industry.

After completion of the course , the students will be able to-

CO-1 Elaborate the use of Artificial Intelligence for the problem solving as Technological driver.

CO-2 Write Python Programmes for solving problems.

CO-3 Analyze given data by using NumPy package of Python.

CO-4 Analyze given data by using Pandas package of Python.

CO-5 Visualize given data set using Matplotlib.

F) **Suggested Course Articulation Matrix:**

Course Outcomes (COs)	**Programme Outcomes (POs)**							**Programme Specific Outcomes (PSOs)**(if any)		
	PO-1 Basic and Discipline Specific Knowledge	**PO-2**Problem Analysis	**PO-3**Design/Development of Solutions	**PO-4**Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**	**PSO-3**
CO-1	-	2	2	-	-	-	1			
CO-2	-	3	3	3	-	-	2			
CO-3	-	3	3	3	-	-	2			
CO-4	-	2	3	3	-	-	2			
CO-5	-	3	3	3	-	-	2			

Legend: High (3), Medium (2), Low (1) and No mapping (-)

G) Scheme of Studies:

CourseCode	CourseTitle	Scheme of Studies (Hours/Week)						
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (SW+ SL)	Total Hours (CI+LI+SW+SL)	Total Credits(C)
		L	T				
2000505B / 2000508B /2000511B	Artificial Intelligence (Basics)	02	-	04	02	08	05

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI : Laboratory Instruction(Includes experiments/practical performances in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

SW: Sessional Work / Term Work(includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCS, spoken tutorials, open educational resources (OERs)

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: SW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Scheme of Assessment:

Course Code	Course Title	Scheme of Assessment (Marks)						Total Marks (TA+SWA+LA)
		Theory Assessment (TA)		Sessional Work Assessment (SWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Sessional Work Assessment (PSWA)	End Sessional Work Assessment (ESWA)	Progressive Lab Assessment(PLA)	End Laboratory Assessment (ELA)	
2000505B / 2000508B /2000511B	Artificial Intelligence (Basics)	30	70	20	30	20	30	200

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

SWA: Sessional Work/ Term work& Self Learning Assessment (Includes assessment related to student performance in self learning, assignments, Seminars, micro projects, industrial visits, any other student activities etc.

Note: Separate passing is must for progressive and end semester assessment for both theory and practical.

Theory: 100 marks
Practical 50 marks

I) Course Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: [2000505B]

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Elaborate the use of Artificial Intelligence TSO 1b. Explain various technological Drivers of Modern AI TSO 1c. Describe Knowledge representation TSO 1d. Classify Intelligent agents TSO 1e. List the characteristics of agents TSO 1f. Apply various search strategies for problem solving	**Unit-1.0. Artificial Intelligence** **Artificial Intelligence:** What is AI?, Types of AI, History of AI, Turing Test, Symbol Systems and the scope of Symbolic AI, Structure of AI, Goals of AI, Importance ofAI, Techniques used in AI, Perception, Understanding and Action**,** Technological drivers of modern AI **Knowledge**: Definition, Knowledge Representation, objectives and requirements, practical aspects of representation, Components **Intelligent Agents**: Agents and Environments, Properties of environments, characteristics of agents, classification of agents **Problem Solving:** Problem Formulation, Goal Formulation, State Space Search,Search Problem, Basic search algorithm,Search Tree, Search strategies – Uninformed and informed search, Breadth First Search, Depth First Search, Best First Search, Constraint Satisfaction Problem (CSP), Backtracking Search.Problem Definitions: N Queen Problem, 8Puzzle Problem, Tic-tac-Toe.	CO-1
TSO 2a. Explain Python tokens and variables TSO 2b. Use the concept of l-value and r-value TSO 2c. Write python program using various data types TSO 2d. Write Program using various operators in Python TSO 2e. Write program using conditional	**Unit-2.0 Python Programming** 2.1 Python character set, Python tokens, variables, concept of l-value and r-value, use of comments. Data types: number (integer, floating point, complex), boolean, sequence (string, list, tuple), none, mapping (dictionary),	CO-2

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
statements. TSO 2f. Use various string functions for problem solving in python program TSO 2g. write programmes using various operations on list TSO 2h. Write programmes by using various operations on Tuples and Dictionary TSO 2i. Create user defined functions TSO 2j. Write python programmes using built-in functions TSO 2k. Describe the procedure to import module in the Python TSO 2l. Describe procedure to Import Library and functions in the Python TSO 2m. Write program using Iterative statements.	mutable and immutable data types Operators: arithmetic operators, relational operators, logical operators, assignment operator, augmented assignment operators. Expressions, statement, type conversion & input/output: precedence of operators, expression, evaluation of expression. **Conditional and Iterative statements:** if, if-else, if-elif-else, for loop, range function, while loop, break and continue statements, nested loops **String, List, Tuples and Dictionary:** String: indexing, string operations (concatenation, repetition, membership & slicing), traversing a string using loops, built-in functions. Lists: introduction, indexing, list operations (concatenation, repetition, membership & slicing), traversing a list using loops, built-in functions, linear search on list of numbers and counting the frequency of elements in a list Dictionary: accessing items in a dictionary using keys, mutability of dictionary (adding a new item, modifying an existing item), traversing a dictionary, built-in functions **Python Functions:** types of function (built- in functions, functions defined in module, user defined functions), creating user defined function, arguments and parameters, default parameters, positional parameters, function returning value(s), flow of execution, scope of a variable (global scope, local scope) **Modules and Packages:** Importing module using 'import' Regular Expressions, Exception Handling, PyPI Python PackageIndex, Pip Python package manager, Importing Libraries and Functions	

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 3a. Explain Data Analytics and its elements TSO 3b. Differentiate Data Analysis and Data Analytics TSO 3c. Explain the use of open source data TSO 3d.Differentiate Qualitative and Quantitative data analysis TSO 3e. Explain procedure to Install NumPy Library TSO 3f. Use NumPy library to perform various operations and functions on array TSO 3g. Write Programs using NumPy for array manipulations	**Unit-3.0 Data Analytics and Computing with NumPy** Data Analytics: Data, Types of Data, Importance of Data, Data Analysis Vs Data Analytics, Types of Data Analytics, Elements of Analytics, Data Analysis Process, Qualitative and Quantitative analyses, Open Source Data. NumPy Library: Introduction, Installation, Ndarray: creating an array, intrinsic creation of an array, Data types, basic operations, aggregate functions, Indexing, slicing, Iterating, Conditions and Boolean arrays, Array manipulation: Joining, splitting, shape changing, sorting, Structured arrays, Reading and Writing array data on a File.	CO-3
TSO 4a. Apply Pandas data structure for data analysis **TSO** 4b. Write Programs using Pandas to perform various operations and functions on series. **TSO** 4c. Perform various operation in a Data Frame columns and rows **TSO** 4d. Write Programme to read and write on CSV, XLS and Text data files **TSO** 4e. Apply various data cleaning operations and prepare data.	**Unit-4.0 Data Analysis with Pandas** Pandas data structures: Series, Declaration, selecting elements, assigning values, Filtering values, operations, mathematical functions, evaluating values, handling missing data, creating series from dictionaries, adding two series. Data Frame: Defining, selecting elements, assigning values, membership, deleting a column, filtering. Index Objects: Indexing, Re-indexing, Dropping, sorting and ranking, Descriptive Statistics Data Loading: Reading and Writing csv, xls, text data files, Data Cleaning and Preparation: Handling missing data, removing duplicates, replacing values, Vectorized String Methods, Hierarchical Indexing, Merging and Combining, Data aggregation and Grouping.	CO-4
TSO 5a. Illustrate the use of Matplotlib and PyPlot package for showing plots and images TSO 5b. Customize plots with Colors, Markers, Line Styles, Limits, Tics, Labels, Legends, Grids TSO 5c. Differentiate various charts based on their applications	**Unit-5.0 Data Visualization with Matplotlib** Data Visualization: Introduction to Matplotlib ,PyPlot package, Figures and Subplots, showing plots and images Customizing Plots: Colors, Markers, Line Styles, Limits, Tics, Labels, Legends, Grids ,Annotating with text, Matplotlib configuration	CO-5

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	Chart types: Line, Bar, stacked bar, Box plots, pie chart , Histogram and Density plots, Scatter plot, Saving Plots to a file, Close and clear plots.	

Note: One major TSO may require more than one Theory session/Period.

K) Laboratory (Practical) Session Outcomes (LSOs) and List of Practical [2000508B]

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
Use various data types and operators to solve given problem Use conditional and iterative statements for solving given problem	1	**Conditional and Iterative statements** 1a. Write a program to generate random numbers between 5 and 10. 1b. Write a program to find the square root of a number. 1c. Write a python program to check if a number is positive, negative or 0. 1d. Write Python program to print all prime numbers between 0-50.	CO-2
2.1Use string functions for performing various string operations	2	**String Handling** 2a. Write a Programme that asks the user for a string with only single space between words, and return number of words in the string. 2b. Write a Program that inputs a line of text and print the count of Vowels in it. 2c. Write a Program that inputs a line of text and print the biggest word in it. 2d. Write a Program that inputs a line of text and print a new line of text where each word of input line is reversed.	CO-2
Use list operations for concatenation, repetition & slicing Perform various operation in the Tuples Perform various operation in the dictionary	3	**List, Tuples and Dictionary** 3a. Write a python program to convert a string to a list. 3b. Write a program to print the largest number in a list. 3c. Given a tuple pairs = ((3,9), (8,4), (3,7), (24,18)), count the number of pairs (a, b) such that both a and b are odd. 3d. Write a program to input a list of numbers and swap elements at the even location with the elements at the odd location. 3e. Write a program to merge two dictionaries.	CO-2
4.1 Use built-in functions to solve given problem	4	**Python Functions** 4a. Write a function to reverse a string. 4b.Write a function to calculate the factorial of a	CO-2

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
4.2 Create user defined functions tosolve given problem		number.	
use basic data structure using NumPy Convert the list and tuple as NumPy array	5.	**Basic data structures in NumPy** 5a. Create a List, set, tuple and dictionary which stores the details of a student (roll no, name, dept, branch, percentage of mark) in Python and print the values. 5b. Convert the list and tuple as NumPy array.	CO-3
Create Arrays in Numpy using different intrinsic methods Performarithmetic operations and mathematical operations using arange and ones intrinsicmethod.	6	**Arrays in NumPy** 6a. Create arrays using different intrinsic methods (ones, zeros, arange, linspace, indice) and print their values. 6b. Check the results of arithmetic operations like add(), subtract(), multiply() and divide() with arrays created using arange and ones intrinsic method. 6c. Check the results of mathematical operations like exp(), sqrt(), sin(), cos(), log(), dot() on an array created using arange intrinsic method.	CO-3
7.1 Apply aggregate functions on data by using Built-in functions in Numpy	7	**Built-in functions in NumPy.** 7a. Load your class Mark list data from a csv (comma separated value) file into an array. Perform the following operations to inspect your array. Len(), ndim, size, dtype, shape, info() 7b. Apply the aggregate functions on this data and print the results. (Functions like min(), max(), cumsum(), mean(), median(), corrcoef(), std())	CO-3
8.1 Handle multiple arrays by applying various operations on arrays	8	**Handling Multiple Arrays** 8a. Create two python NumPy arrays (boys, girls) each with the age of nstudents in the class. 8b. Get the common items between two python NumPy arrays. 8c. Get the positions where elements of two arrays match. 8d. Remove from one array those items that exist in another. 8e. Extract all numbers between a given range from a NumPy array.	CO-3
9.1 Apply indexing on the given set of data	9	**Indexing in NumPy** 9a. Load your class Mark list data from a csv file into an array. 9b. Access the mark of a student in a particular subject using indexing techniques. 9c. Select a subset of 2D array using fancy indexing (indexing using integer arrays	CO-3

Practical/Lab Session Outcomes(LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
Create series using list and dictionary in pandas Print different values from series.	10	**Working with a Series using Pandas** 10a. Create a series using list and dictionary. 10b. Create a series using NumPy functions in Pandas. 10c. Print the index and values of series. 10d. Print the first and last few rows from theseries.	CO-4
11.1 Perform various operation in aData Frame rows	11	**Working with Data Frame Rows** 11a. Slicing Data Frame using loc and iloc.11b. Filter multiple rows using isin. 11c. Select first n rows and last n rows 11d. Select rows randomly n rows and fractionsof rows (use df. sample method) 11e. Count the number of rows with each unique value of variables 11f. Select nlargest and nsmallest values.11g. Order/sort the rows	CO-4
12.1 Apply different techniques tomerge and combine data	12	**Merge and combine data** 12a. Perform the append, concat and combinefirst operations on Data Frames. 12b. Apply different types of merge on data. 12c. Use a query method to filter Data Frame with multiple conditions.	CO-4
Create Linear Plot to identify various relation in the data using Matplotlib Create Scatter Plot to identify various relation in the data using Matplotlib	13	**Consider the Salary dataset, which contains 30observations consisting of years of workingexperience and the annual wage. Download thedata set from** https://www.kaggle.com/rohankayan/years-of- experience-and-salary-dataset 13a. Create a linear plot to identify the relationship between years of workingexperience and the annual wages withsuitable title, legend and labels. 13b. Create a scatter plot to identify the relationship between years of working experience and the annual wages with title , legend and labels. 13c. Also distinguish between observations that have more than 5 years of working experience and observations that have lessthan 5 years of working experience by using different colors in one single plot.	CO-5
14.1 Plot Bar graph by Changing	14	**Consider the Iris dataset, where**	

Practical/Lab Session Outcomes(LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
		of the Set osa iris class using a bar chart. 14b. Format the obtained bar graph by Changing the color of each bar, Change the Edge color, Line width and Line style.	

L) Sessional Work and Self Learning: [2000511B]

a. Assignments: Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

b. Micro Projects:

1. Handing Two-dimensional array in NumPy
Download the data set from
https://archive.ics.uci.edu/ml/machine-learning-databases/iris/iris.datahttps://www.kaggle.com/arshid/iris-flower-dataset

a. Import iris dataset with numbers and texts keeping the text intact into python NumPy.
b. Convert the 1D iris to 2D array (iris2d) by omitting the species text field.
c. Find the number and position of missing values in iris2d's sepal_length
d. Insert np.nan values at 20 random positions in iris 2d dataset
e. Filter the rows of iris2d that has petal_length> 1.5 and sepal_length< 5.0

Expected Outcome(Use various operations on two dimensional arrays in NumPy)

2. Handling missing data and duplicates in Pandas
a. Identify rows with missing data (isnull(), notnull()) and replace NA/Null data with a given value.
b. Drop rows and columns with any missing data (dropna(), dropna(1))
c. Find duplicate values and drop duplicates.
d. Fill the missing values using forward filling and backward filling.
e. Replace the missing value with new value and write the dataframe to a CSV file in the local directory.

Expected Outcomes (a. Identify missing data, b. Find Duplicates values, c. Write the dataframe to a CSV file in the local directory.)

3. Working with Data Frame Columns
a. Create and print a Data Frame.
b. Find the descriptive statistics for each column.
c. Group the data by the values in a specified column, values in the index.
d. Set Index and columns in a Data Frame.
e. Rename columns and drop columns
f. Select or filter rows based on values in columns.
g. Select single and multiple columns with specific names

Expected Outcome (Perform various operation in a Data Frame columns)

4. Indexing & Sorting in NumPy
a. Load your class Mark list data from a csv file into an array.
b. Sort the student details based on Total mark.

c. Print student details whose total marks is greater than 250 using Boolean indexing.

Expected Outcomes (a. Sort the given set of data, b. Use indexing in an array)

5. **Array Slicing in NumPy**
   a. Load your class Mark list data into an array called “marks” to store students roll num, subject marks and result.
   b. Split all rows and all columns except the last column into an array called “features”.
   c. Split the marks array into 3 equal-sized sub-arrays each for 3 different subject marks.
   d. Split the last column into an array “label”.
   e. Delete the roll num column from the marks array and insert a new column student name in its place.

   Expected Outcome (Use array slicing in NumPy for the given set of data)

6. Consider the Iris dataset, where observations belong to either one of three iris flower classes.
   Download the data set from
   https://www.kaggle.com/arshid/iris-flower-dataset

   a. Visualize the Histogram for each feature (Sepal Length, Sepal Width, petal Length & petal Width) separately with suitable bin size and color.
   b. Plot the histograms for all features using subplots to visualize all histograms in one single plot. Save the plot as JPEG file.
   c. Plot the box plots for all features next to each other in one single plot. Perform 3D printing of plastic casing of inhaler used by Asthma patients and estimate the cost.

   Expected Outcomes (a. Plot the Histogram for the various features using subplot, b. Plot the box plots for all features next to each other in one single plot)

c. Other Activities:

1. **Lab Activities**
   - Install Python IDE and important Python Libraries
   - Install Anaconda and find the features of Jupyter Notebook.
   - Import various module using 'import '
   - Use Pip Python package manager.
   - Import Libraries and Functions in Python

2. **Seminar Topics:**
   - Technological rivers of modern Artificial Intelligence
   - Intelligent Agents and Environments in Artificial Intelligence
   - Various Search Strategies
   - Python for Data Science
   - Python Libraries and Packages used in data Science
   - Data Visualisation
   - Various data set available over Internet

3. **Self-learning topics:**
   - Use of AI in Engineering and Technology
   - Data Science and Machine Learning
   - Problem and Goal Formulation
   - Search strategies
   - Breadth First Search and Depth First Search
   - Back tracking Search

- N Queen and 8 Puzzle Problem

M) Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and sessional work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		**Sessional Work Assessment (SWA)**			**Lab Assessment (LA)#**	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	**End Theory Assessment (ETA)**	**Sessional Work & Self Learning Assessment**			**Progressive Lab Assessment (PLA)**	**End Laboratory Assessment (ELA)**
			Assignments	**Micro Projects**	**Other Activities***		
CO-1	20%	20%	20%	--	30%	--	--
CO-2	10%	10%	20%	--	20%	20%	20%
CO-3	20%	20%	20%	30%	20%	20%	20%
CO-4	30%	30%	20%	20%	30%	30%	30%
CO-5	20%	20%	20%	50%	--	30%	30%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

* : Other Activities include self learning, seminar, visits, surveys, product development, software development etc.

**: Mentioned under point- (N)

\# : Mentioned under point-(O)

Note: For indirect assessment of COs, Course exit survey can be used which comprises of questions related to achievement of each COs.

N) Specification Table for End Semester Theory Assessment: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and sessional work for ensuring CO attainment. The response/performance of the student in each of these designed activities is to be assessed to calculate CO attainment.

Unit Title and Number	Relevant COs Number(s)	Total Marks	ETA (Marks)		
			Remember (R)	**Understanding (U)**	**Application & above (A)**
Unit-1.0. Artificial Intelligence	CO-1	15	7	5	3
Unit-2.0. Python Programming	CO-2	15	4	3	8
Unit-3.0. Data Analytics and Computing with NumPy	CO-3	14	3	3	8
Unit-4.0. Data Analysis with Pandas	CO-4	13	3	3	7
Unit-5.0. Data Visualization with Matplotlib	CO-5	13	3	3	7
Total Marks		**70**	**20**	**17**	**33**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Specification Table for Laboratory (Practical) Assessment:

SN	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA (%)	PDA (%)	
1.	Conditional and Iterative statements	CO-2	-	80	20
2.	String handling	CO-2	-	80	20
3.	List, Tuples and Dictionary	CO-2	20	70	10
4.	Python Functions	CO-2	-	80	20
5.	Basic data structures in NumPy	CO-3	-	80	20
6.	Arrays in NumPy	CO-3	-	80	20
7.	Built-in functions in NumPy.	CO-3	20	70	10
8.	Handling Multiple Arrays	CO-3	20	70	10
9.	Indexing in NumPy	CO-3	-	70	30
10.	Working with a Series using Pandas	CO-4	-	80	20
11.	Working with DataFrame Rows	CO-4	20	60	20
12.	Merge and combine data	CO-4	40	50	10
13.	Consider the Salary dataset, which contains 30 observations consisting of years of working experience and the annual wage.	CO-5	80	10	10
14.	Consider the Iris dataset, where observations belong to either one of three iris flower classes.	CO-5	80	10	10

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Instructional/Implementation Strategies: Different Instructional/ ImplementationStrategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Group Discussion, Portfolio Based Learning, Live Demonstrations in Classrooms, Lab, Information and Communications Technology(ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources(OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	Computer Systems	Desktop Computers with i3 processor, 16 GB RAM, 512 GB HDD	S.No. 1 to 14
2.	Online Python IDE	https://www.online-python.com/	S.No. 1 to 14
3.	Jupyter Notebook	Download from https://jupyter.org/	S.No. 1 to 14
4.	Pip Python package manager	Download Pip 22.3 From https://pypi.org/project/pip/	S.No. 1 to 14
5.	Various modules, Libraries and Packages	NumPy, Pandas, Matplotlib,PyPlot package	S.No. 1 to 14

R) Suggested Learning Resources:

(a) Suggested Books :

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Artificial Intelligence Basics - A Non-Technical Introduction	TomTaulli	Apress(2019)
2.	Fundamentals of artificial Intelligence	Chowdhary K. R	Springer 2020
3.	Artificial Intelligence A Modern approach	Stuart J. Russell and Peter Norvig	PrenticeHall 2010, 3rdEdition
4.	Introduction to Computing and Problem Solving using Python	E. Balagurusamy	McGraw Hill Education(India)Pvt. Ltd. 1st Edition /2016
5.	Learning Python Programming	Jeffrey Elkner, Allan B.Downey, Chris Meyers	Samurai Media Limited. 2016
6.	Python Programming	Ashok Namdev Kamthane and Amit Ashok Kamthane	McGraw Hill Education(India) Pvt.Ltd.2020, 2nd Edition
7.	Programming in Python	Dr. Pooja Sharma	BPB Publications 2017
8.	Taming Python By Programming	Jeeva ose	Khanna Book Publishing Co(P)Ltd , 2017, Reprinted2019
9.	Python Data Analytics	Fabio Nelli	Apress,2015
10.	Python for Data Analysis: Data Wrangling with Pandas, Numpy, and IPython	Wes McKinney	O'REILLY 2018,SecondEdition

(b) Suggested Open Educational Resources (OER):

1. NPTEL Web Content- Artificial Intelligence, Prof. P. Mitra, Prof. S. Sarkar, IIT Kharagpur URL: https://nptel.ac.in/courses/106/105/106105078/
2. https://www.learnpython.org
3. www.python.org
4. https://www.tutorialspoint.com/python

Note: Teachers are requested to check the creative commons licence status/ financial implications of the suggested OER, before use by the students.

(c) Others: (If any)

Data Source:

- https://archive.ics.uci.edu/ml/machine-learning-databases/auto-mpg/
- https://archive.ics.uci.edu/ml/machine-learning-databases/iris/iris.data
- https://www.kaggle.com/arshid/iris-flower-dataset
- https://www.kaggle.com/rohankayan/years-of-experience-and-salary-dataset

S) Course Curriculum Development Team(NITTTR)

- Dr. Sanjay Agrawal(Coordinator)
- Dr. R. K. Kapoor(Co-coordinator)

******

A) **Course Code** : **2000505C / 2000508C / 2000511C**

B) **Course Title** : **Internet of Things (Basic)**

C) **Pre- requisite Course(s)** : **Digital Electronics, Electronics Circuits, Fundaments of Computers and Computer networks**

D) **Rationale:**

The Internet of Things (IoT) is the upcoming field that has the capability to connect everything on the earth. This course focuses on the development of IoT concepts such as sensing, actuation with implementation of communication protocols.

The course also focuses on real life aspects of IoT and how to integrate it in real life projects. The course will simplify the concept of IoT by using the Node MCU board for IoT application development. In this course students will learn about the use of Node MCU and its applications as a beginner/intermediate in the field of IoT. Apart from this, students will learn about the APIs, by using which integration of features like send Email, WhatsApp messages and notification based on certain events in projects is possible. Overall, this course covers both hardware and software aspects of IoT with practical exposure.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

CO-1 Describe the functions of each block of the basic IoT system

CO-2 Explain communication protocol used in IoT and its applications

CO-3 Use appropriate sensors for the specific measurement through the IoT platform

CO-4 Explain APIs, client-server connections and its integration in real life applications.

CO-5 Build and test a complete, working IoT system involving prototyping, programming, and data analysis

F) Suggested Course Articulation Matrix:

Course Outcomes (COs)	**Programme Outcomes (POs)**							**Programme Specific Outcomes (PSOs)** (if any)		
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**	**PSO-3**
CO-1	3	-	-	-	-	-	-			
CO-2	1	2	2	2	2	-	-			
CO-3	1	3	2	2	2	2	2			
CO-4	1	1	2	3	-	2	2			
CO-5	1	1	3	2	2	3	3			

Legend: High (3), Medium (2), Low (1) and No mapping (-)

G) Scheme of Studies:

CourseCode	CourseTitle	Scheme of Studies (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (SW+ SL)	Total Hours (CI+LI+SW+SL)	Total Credits(C) (CI+LI+SW+SL)
		L	T				
2000505 C / 2000508 C / 2000511C	**Internet of Things (Basic)**	02	-	04	02	08	05

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI : Laboratory Instruction (Includes experiments/practical performances in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

SW: Sessional Work/Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCS, spoken tutorials, open educational resources (OERs)

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: SW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Scheme of Assessment:

Course Code	Course Title	Scheme of Assessment (Marks)						Total Marks (TA+SWA +LA)
		Theory Assessment (TA)		Sessional Work Assessment (SWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment(ETA)	Progressive Sessional Work Assessment (PSWA)	End Sessional Work Assessment (ESWA)	Progressive Lab Assessment(PLA)	End Laboratory Assessment (ELA)	
2000505 C / 2000508 C / 2000511C	Internet of Things (Basic)	30	70	**20**	**30**	20	30	200

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

SWA: Sessional Work/Term work& Self Learning Assessment (Includes assessment related to student performance in self learning, assignments, Seminars, micro projects, industrial visits, any other student activities etc.

Note: Separate passing is must for progressive and end semester assessment for both theory and practical.

Theory: 100 marks
Practical 50 marks

I) Course Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: [2000505C]

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.1.a. Describe the concept of IoT. TSO.1.b. Explain the functions of each block of the Basic IoT system. TSO.1.c. Compare features of various IoT platforms TSO.1.d. List IoT Real time Applications. TSO.1.e. Describe the functioning of given real-time applications	**Unit-1.0 Introduction to IoT** Basics of IoT, concepts of IoT, History of IoT Basic IoT System and its building blocks Various platforms for IoT (e.g. AWS, AZURE,GCP) Introduction to Python programming andIoT software Applications of IoT	CO-1 and CO-5
TSO.2.a.Explain various communication protocols. TSO.2.b.Explain working and application of blue tooth TSO.2.c.Explain working and application of ZigBee TSO.2.d.Explain working and application of LoRa TSO.2.e.Explain working and application of Wi-fi	**Unit 2. IoT Communication protocols** Basics of given communication protocol along with its applications Explain Communication Protocols MQTT Bluetooth Low Energy ZigBee LoRa Wi-fi	CO-1 and C02
TSO.3.a. Differentiate between sensor and Actuator. TSO.3.b. Classify IoT sensors on the basis of their application. TSO.3.c. Describe the function of each block of Node MCU. TSO.3.d. Explain the procedure to connect sensors with Node MCU.	**Unit-3.0 Sensors and Hardware for IoT** Sensors and Actuators, Transducers, Classifications of sensors, IoT Sensors Development Boards, classifications, andbasics of wireless networks, WiFi libraries Introduction to node MCU, block diagram, functions, interfacing with sensors and publishing data on webserver Device integration with node MCU Interfacing of sensors with boards	**CO-1, CO-3 and CO-5**
TSO.4.a. Define APIs and its uses TSO.4.b.Explain working and application of REST. TSO.4.c.Explain working and application of SOAP TSO.4.d.Explain working and application of json TSO.4.e.Explain the integration of API in IoT application development.	**Unit.4 IoT APIsand its Integration** Explain APIs and its use Explanation of given IoT APIs along with its applications MQTT, Broker, subscriber, publisher **REST** **SOAP** **4.5 JSON** **4.6 Programming API using Python**	**CO-1 and CO-4**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.5.a. Differentiate between industrial IoT and IoT. TSO.5.b. Describe the applications of IoT in the medical field. TSO.5.c. Describe the medical applications of IoT in the agriculture field. TSO.5.d. Describe the innovative IoT applications.	**Unit. 5 IoT Applications**: - Industrial IoT and Internet of everything IoT for consumer electronics products IoT for Medical applications IoT for Agriculture IoT for security and Law enforcement	**CO-1 and CO-5**

Note: One major TSO may require more than one Theory session/Period.

K) Laboratory (Practical) Session Outcomes (LSOs) and List of Practical [2000508 C]

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSOs 1.1 List various IoT platforms. List Down broad features of given platforms. List IoT based features in python language.	1.	Prepare a list of platforms used for IoT. Prepare a list of features of above IoT platforms. Prepare a list of features provided by python language for IoT applications.	**CO-1**
LSOs 2.1 Arduino connection with Arduino IDE. Connect Bluetooth with Arduino. verification of data communication with Bluetooth.	2.	Establish connectivity between various components of IoT. Establish connection between Arduinoand Bluetooth module. Establish connection using WiFi	**CO-2**
LSO 3.1 Measure the temperature of the given sensor. LSO 3.2 Measure the humidity of the given sensor. LSO 3.3 Measure the pressure of the given sensor.	3.	Publish data on the IoT platform. Measure the temperature of a remotely located temperature sensor Using IOT based temperature data-monitoring system. Measure the humidity of a remotely located humidity sensor Using IOT based humidity data-monitoring system. Measure the pressure of a remotely located pressure sensor Using IOT based pressure data-monitoring system.	**CO-3**
LSO 4.1 Working with APIs. LSO 4.2 Implementation of APIs using POSTMAN Application.	4	Download and Configure POSTMAN Application Verify REST APIs through POSTMAN. Verify JSON APIs through POSTMAN. Verify SOAP APIs through POSTMAN.	**CO-4**
LSO 5.1 Identification of components for various applications. LSO 5.2 Estimate the cost for components.	5.	Identify components for given project Estimate the cost to make Project working.	**CO-5**

L) Sessional Work and Self Learning: [2000511C]

a. **Assignments**: Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

b. Micro Projects:

1. Prepare a report on IoT Systems using Internet data.
2. Market survey to identify various types of IoT sensors and its pricing.
3. Interface IR sensor with Arduino and send the data to Arduino cloud.
4. Send IoT data using Node MCU to things Speak cloud.
5. Interface Bluetooth module with Arduino and send data using the Bluetooth module.

c. Other Activities:

1. Seminar Topics: - "Future of IoT"
   "Technologies for IoT ", "Smart City and IoT"
2. Visit to industry for latest IoT setup in industrial process.
3. Surveys of market for availability of various types of sensors and its pricing.
4. Product Development: Development of projects for real life problem solution using IoT.
5. Software Development: various open source platform operations.

6. Self-learning topics:

1. IoT hardware and their use for various applications
2. IoT sensors technical specifications
3. IoT enabled services

M) Course Evaluation Matrix:

The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and sessional work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		**Sessional Work Assessment (SWA)**			**Lab Assessment (LA)#**	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	**End Theory Assessment (ETA)**	**Sessional Work & Self Learning Assessment**			**Progressive Lab Assessment (PLA)**	**End Laboratory Assessment (ELA)**
			Assignments	**Micro Projects**	**Other Activities***		
CO-1	10%	10%	20%	--	33%	10%	20%
CO-2	15%	10%	20%	--	33%	15%	20%
CO-3	30%	30%	20%	--	34%	15%	20%
CO-4	20%	30%	20%	50%	--	30%	20%
CO-5	25%	20%	20%	50%	--	30%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

* : Other Activities include self learning, seminar, visits, surveys, product development, software development etc.

**: Mentioned under point- (N)

\# : Mentioned under point-(O)

Note: For indirect assessment of COs, Course exit survey can be used which comprises of questions related to achievement of each COs.

N) Specification Table for End Semester Theory Assessment: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and sessional work for ensuring CO attainment. The response/performance of the student in each of these designed activities is to be assessed to calculate CO attainment.

Unit Title and Number	Relevant COs Number(s)	Total Marks	ETA (Marks)		
			Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0. Introduction to IoT	CO-1	5	3	2	-
Unit-2.0. IoT Communicationprotocols	CO-2	9	4	3	2
Unit-3.0. Sensors and Hardware for IoT	CO-3	19	5	6	8
Unit-4.0 IoT APIs and its Integration	CO-4	19	5	5	9
Unit-5.0. IoT Applications	CO-5	18	3	6	9
	Total Marks	**70**	**20**	**22**	**28**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Specification Table for Laboratory (Practical) Assessment:

SN	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA (%)	PDA (%)	
1.	Prepare a list of platforms used for IoT.	CO-1	60	30	10
2.	Prepare a list of features of above IoT platforms.	CO-1	60	30	10
3.	Prepare a list of features provided by python language for IoT applications.	CO-1	60	30	10
4.	Establish connectivity between various components of IoT.	CO-2	60	30	10
5.	Establish connection between Arduino and Bluetooth module.	CO-2	60	30	10
6.	Establish connection using WiFi	CO-2	70	20	10
7.	Publish data on the IoT platform.	CO-3	70	20	10
8.	Measure the temperature of a remotely located temperature sensor Using IOT based temperature data-monitoring system.	CO-3	60	40	10
9.	Measure the humidity of a remotely located temperature sensor Using IOT based temperature data-monitoring system.	CO-3	60	40	10
10.	Measure the pressure of a remotely located temperature sensor Using IOT based temperature data-monitoring system.	CO-3	60	40	10
11.	Publish the data using Mqtt	CO-4	60	30	10
12.	Download and Configure POSTMAN Applications	CO-4	60	30	10
13.	Verify REST APIs through POSTMAN.	CO-4	60	30	10
14.	Verify JSON APIs through POSTMAN.	CO-4	60	30	10
15.	Verify SOAP APIs through POSTMAN.	CO-4	60	30	10
16.	Identify components for given project	CO-5	50	40	10
17.	Estimate the cost to make Project working.	CO-5	50	40	10

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources(OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1	Bluetooth Modem- BlueSMiRF Silver	Sparkfun Bluetooth modem	As mentioned above list
2	Postman Software	Open-source downloadable	
3	Node MCU board	Generic	
4	IoT free cloud	Arduino cloud/Thing Speak/Blynk	
5	ATAL Lab Package-1 Package-2 Package-4	As per the list as address below ATAL Equipment list' (http://aim.gov.in/guidelines-for-school.php).	

R) Suggested Learning Resources:

(a) Suggested Books :

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1	Internet of Things Architecture and Design Principles	Raj Kamal	Mc Graw Hills, New Delhi ISBN 13: 978-93-90722-38-4

2	Internet of things (IoT) : technologies, applications, challenges and solutions	Edited By BK Tripathy , J Anuradha	CRC Press ,ISBN 9780367572921, June 30, 2020	
3	Internet-of-Things (IoT) Systems: Architectures, Algorithms, Methodologies	by Dimitrios Serpanos & Marilyn Wolf	Springer; 1st ed. 2018 edition (17 January 2018)	
4	Custom Raspberry Pi Interfaces: Design and build hardware interfaces for the Raspberry	Pi by Warren Gay	Apress; 1st ed. edition (23 February 2017), ISBN-10 : 9781484224052, ISBN-13 : 978-1484224052	
5	'Learning Internet of Things',	Peter Waher	Packt Publishing, 2015, ISBN 9781783553532, https://lib.hpu.edu.vn/handle/123456789/31693	
6	Sensors, Actuators and Their Interfaces,	N. Ida	Scitech Publishers, 2014.	

(b) Suggested Open Educational Resources (OER):

1. nptel.iitm.ac.in/courses/.../IIT.../lecture%2023%20and%2024.htm
2. en.wikipedia.org/wiki/Shear and moment diagram
3. www.freestudy.co.uk/mech%20prin%20h2/stress.pdf
4. www.engineerstudent.co.uk/stress_and_strain.html
5. https://www.iit.edu/arc/workshops/pdfs/Moment_Inertia.pdf
6. https://www.veritis.com/blog/aws-vs-azure-vs-gcp-the-cloud-platform-of-your-choice/
7. https://wiki.python.org/moin/TimeComplexity
8. www.engineerstudent.co.uk/stress_and_strain.html
9. https://www.iit.edu/arc/workshops/pdfs/Moment_Inertia.pdf
10. Amini, P. (2014). Sulley: Pure Python fully automated and unattended fuzzing frame- work.
11. https://github.com/OpenRCE/sulley

Note: Teachers are requested to check the creative commons licence status/ financial implications of the suggested OER, before use by the students.

(c) Others: (If any)

1. Learning Packages
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

S) Course Curriculum Development Team(NITTTR)

- Dr. M. A. Rizvi(Coordinator)
- Dr. Anjali Potnis(Co-coordinator)

******

A)	**Course Code**	**:**	**2000505D / 2000508D / 2000511D**
B)	**Course Title**	**:**	**Drone Technology (Basics)**
C)	**Pre- requisite Course(s)**	**:**	
D)	**Rationale**	**:**	

Rapid technological innovation has provided users cutting-edge products at affordable prices. Traditionally, drones had been limited to military use due to high costs and technical sophistication. In recent years, the drone has number of commercial uses and are also proving to be extremely beneficial in places where a man cannot reach or is unable to perform in a timely and efficient manner. Today, drones are used in construction, photography, agriculture, defense, environmental studies and monitoring and other industries to protect the skies, repopulate forests and accomplish much more on a huge scale. This course will acquaint the student with the basic drone technology and applicable drone rules and regulations in India. Considering that the main operational areas of diploma holders, it is essential that he should be exposed to basic drone designing, programming, operating, maintaining and using them safely.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/laboratory/workshop/field/ industry.

After completion of the course, the students will be able to-

CO-1 Operate a drone safely by applying appropriate drone rules and regulations.

CO-2 Design the structure of drone with drone components and equipment.

CO-3 Interface flight controller board with sensors, ESC and radio communication unit in drone technology.

CO-4 Use drone simulator and identify different types of ports and connectors of drone.

CO-5 Use python programming while drone designing.

F) Course Articulation Matrix:

Course Outcomes (COs)	**Programme Outcomes (POs)**							**Programme Specific Outcomes (PSOs)**(if any)		
	PO-1 Basic and Discipline Specific Knowledge	**PO-2**Problem Analysis	**PO-3**Design/ Development of Solutions	**PO-4**Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**	**PSO-3**
CO-1	2	-	-	-	3	-	2			
CO-2	3	2	3	3	-	-	-			
CO-3	3	2	3	3	-	-	-			
CO-4	2	-	-	2	-	3	2			
CO-5	-	2	2	3	-	-	-			

Legend: High (3), Medium (2), Low (1) and No mapping (-)

G) Scheme of Studies:

CourseCode	CourseTitle	Scheme of Studies (Hours/Week)						
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (SW+ SL)	Total Hours (CI+LI+SW+SL)	Total Credits(C) (CI+LI+SW+SL)
		L	T				
2000505D / 2000508D / 2000511D	Drone Technology (Basics)	02	-	04	02	08	05

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI : Laboratory Instruction(Includes experiments/practical performances in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours:Hours of engagement by learners, other than the contact hours for ensuring learning.

SW: Sessional Work/Term work(includesassignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCS,spoken tutorials, open educational resources (OERs)

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: SW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Scheme of Assessment:

Course Code	Course Title	Scheme of Assessment (Marks)						Total Marks (TA+SWA+LA)
		Theory Assessment (TA)		Sessional Work Assessment (SWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment(ETA)	Progressive Sessional Work Assessment (PSWA)	End Sessional Work Assessment (ESWA)	Progressive Lab Assessment(PLA)	End Laboratory Assessment (ELA)	
200505D / 200508D / 200511D	3D Printing and Design (Basics)	30	70	**20**	**30**	20	30	200

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

SWA: Sessional Work/Term work& Self Learning Assessment (Includes assessment related to student performance in self-learning, assignments, Seminars, micro projects, industrial visits, any other student activities etc.

Note: Separate passing is must for progressive and end semester assessment for both theory and practical.

I) Course Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: [2000505D]

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Describe the various historical evolutionary steps of drone technology TSO 1b. Explain Drone motion based on principle of aerodynamics. TSO 1c. Classify different types of drones and make chart of its application, advantages and disadvantages. TSO 1d. Develop attitude to follow proper rules and regulations of drones flying in India. TSO 1e. Explore future prospects of drones in India.	**Unit-1.0Introduction to Drone Technology** Introduction to Drones and UAV • Definition • History • Drone in Indian aspect Introduction to Flight Dynamics Various types of Drones and their respective Applications • Multirotor drones • Fixed wing structure Drone flights using an understanding of FAA • DGCA • Digital sky platform • RPTO 1.5 Drone regulations-No drone zones	CO-1
TSO 2a. Explain the use and function of different types of Drone components. TSO 2b. Select suitable drone frame and propellers for given application. TSO 2c. Explain working principle and function of different sensors used indrone technology. TSO 2d. Write use of Gyro sensor and Accelerometer in drone. TSO 2e. Describe different types and capacity of Battery used in various drone applications. TSO 2f. State the selection criteria of motor for given drone application. TSO 2g. Write advantage of BLDC motors in making of Drones.	**Unit-2.0Droneand its components** Drones components • Drone frame • Propellers Sensors • Gyro sensor and Accelerometer • Speed and Distance Sensor • Temp sensor • Barometer • TOF Sensor Battery • Types and Capacity Motors • Motor types • Motor capabilities • Application of BLDC motors in drones	CO-2
TSO 3a. Explain four types of motion used in drone's operation. TSO 3b. Describe the working and applications of Electronic speed controller. TSO 3c. Explain the working principle of Flight controller unit used in drone.	**Unit-3.0 Drone controller and motion** Propulsion and Vertical Motion Controller and Flying Instructions • Electronic speed Controller (ESC) • Flight Controller Board(FCB)	**CO-3**

Major Theory Session Outcomes (TSOs)		Units	Relevant COs Number(s)
TSO 3d.	Explain Radio communication unit used in drone.	Radio Communication • Transmitter and Receiver for radio signal	
TSO 3e.	Explain the communication of Flight controller board with motor, ESC and sensors with suitable diagram		
TSO 4a.	Describe utility of different communication port used in drone.	**Unit-4.0 Connections and Interfaces of Devices in Drone and Drone Simulator** Communication Port • PWM • RS232, RS422, RS485 • UART • CAN • I2C Different types of connectors and its specification Drone Simulator software Drone simulator Hardware	**CO-4**
TSO 4b.	Identifydifferent types of connectors and write their specifications.		
TSO 4c.	Explain the use of drone simulator software and hardware.		
TSO 5a.	Write basic code in Python.	**Unit-5.0 Introduction to Python for Drone** Python programing refreshers for IoT, AI and Drone Integration of devices with cloud services Microsoft Azure, AWS	**CO-5**
TSO 5b.	Explain structure and components of a Python program.		
TSO 5c.	write syntax of loops and decision statements in Python.		
TSO 5d.	Explain steps to create functions and pass arguments in Python.		

K) Laboratory (Practical) Session Outcomes (LSOs) and List of Practical [2000508D]

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1 Choose suitable materials for making drone frame.	1.	Determine the strength of materials used in drones frame.	CO-2
LSO 2 Select suitable materials for making drone propellers.	2.	Determine the strength of materials used in drones Propellers.	CO-2
LSO 3 Use appropriate battery as per need of flight time for specific drone application.	3.	Test different parameters of batteries used in drones	CO-2
LSO 4 Identify suitable motors as per payload of specific drone application.	4.	Test motors suitable for specific Drone application.	CO-2
LSO 5 Operate Gyro sensor and Accelerometer.	5.	Test and measure Gyro sensor and Accelerometer and their characteristics.	CO-2
LSO 6.1 Identify different sensors based on their characteristics. LSO 6.2 Interface different types of sensor in drone.	6.	Test different sensors and their characteristics with Microcontroller based Flight controller board.	CO-2, CO-3
LSO 7 Demonstrate four type of drone motion.	7.	Determine thrust/torque of motor by changing different drone motion	CO-2, CO-3
LSO 8.1 Configure Flight control board (FCB) LSO 8.2 Demonstrate use of Flight control board (FCB)	8.	Test and troubleshoot Flight control board (FCB).	CO-3
LSO 9.1 Measure various parameters of sensor LSO 9.2 Interface sensor with flight controller board.	9.	Test and perform communication of Flight control board (FCB) with sensor	CO-3, CO-2
LSO 10 Use motor with flight controller board.	10.	Test and perform communication of Flight control board (FCB) with motor.	CO-3, CO-2
LSO 11 Interface ESC with flight controller board.	11.	Test and perform communication of Flight control board with ESC.	CO-3
LSO 12 Configure radio communication device to control drones	12.	Test and perform communication of Flight control board with RF transceiver.	CO-3
LSO 13.1 Identify different types of ports and connectors of drone. LSO 13.2 Assemble drone component.	13.	Test Hardware assembly for drone.	CO-4 CO-3
LSO 14.1 Identify different motions in drone simulator. LSO 14.2 Operate drone in simulator for specific task	14.	Perform different motion in drone simulator.	CO-4
LSO 15.1 Write code of loop and decision statement in python. LSO 15.2 Interpret loop and decision statement LSO 15.3 Debug code of loop and decision statement	15.	Build and run loops and decision statements for specific application in Python.	CO-5
LSO 16.1 Make function in python. LSO 16.2 Interpret given function statement	16.	Build and Run functions for specific application and pass arguments in Python.	CO-5

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 16.3 Debug code of function in python			
LSO 17.1 Identify python programming steps	17.	Write basic programming in python to	CO-5,
to interface drone components.		interface different component of Drones.	CO-3
LSO 17.2 Identify error in python program			
LSO 17.3 Debug the given python program			

L) Sessional Work and Self Learning: [2000511D]

a. Assignments: Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

b. Micro Projects:

1. Design drone for simple application.
2. Test different sensors, their characteristics and make chart which are used in different drones' applications.
3. Download 5 videos on drone design with different components. Watch them and write report on it.
4. Write report on Drone application for precision agriculture.
5. Survey nearby electronics shop and Prepare report of list of drone component and its specification.
6. Visit nearby tool room, small industry, Drone training institute facilities. Prepare report of visit with special comments of drone technology used, material used, cost of printed component.

c. Other Activities:

1. Seminar Topics-History of Drone, Drone regulations, Proximity sensor, Bernoulli's principle apply in drone, Radio communication used in drones, Drone Simulator, Python Programming.
2. Visits: Visit nearby tool room, small industry, Drone training institute facilities. Prepare report of visit with special comments of drone technology used, material used, cost of printed component.
3. Surveys: Survey nearby electronics shop and Prepare report of list of drone component and its specification and explore Drone simulator.
4. Product Development
5. Software Development

d. Self learning topics:

1. History of Drones
2. Drone in Indian aspect
3. Drone regulations
4. Principle of aerodynamics for Drones
5. Drone simulator

M) Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and sessional work for ensuring CO attainment. There sponse /performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

	Course Evaluation Matrix				
	Theory Assessment (TA)**		Sessional Work Assessment (SWA)	Lab Assessment (LA)#	
	Progressive Theory Assessment	End Theory Assessment (ETA)	Sessional Work & Self Learning Assessment	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)

COs	(PTA) Class/Mid Sem Test		Assignments	Micro Projects	Other Activities*		
CO-1	10%	10%	10%	--	10%	-	-
CO-2	30%	30%	30%	33%	30%	30%	30%
CO-3	30%	30%	30%	34%-	30%	30%	30%
CO-4	15%	10%	15%	-	15%	20%	20%
CO-5	15%	20%	15%	33%	15%	20%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

* : Other Activities include seminar, visits, surveys, product development, software development etc.

**: Mentioned under point- (N)

\# : Mentioned under point-(O)

Note: To calculate CO attainment 80% weightage of direct assessment tools and 20% of indirect assessment tools may be taken.

N) Specification Table for End Semester Theory Assessment: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and sessional work for ensuring CO attainment. The response/performance of the student in each of these designed activities is to be assessed to calculate CO attainment.

Unit Title and Number	Relevant COs Number(s)	Total Marks	ETA (Marks)		
			Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0. Introduction to Drone Technology	**CO-1**	08	03	02	03
Unit-2.0. Drone and its component	**CO-2**	20	05	07	08
Unit-3.0. Drone controller and motion	**CO-3**	20	05	07	08
Unit-4.0. Connections and Interfaces ofDevices in Drone and Drone Simulator	**CO-4**	08	03	02	03
Unit-5.0. Introduction to Python for Drone	**CO-5**	14	04	04	06
	Total Marks	**70**	**20**	**22**	**28**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Specification Table for Laboratory (Practical) Assessment:

S.No	Laboratory Practical Titles	Relevant COs Number(s)	PLA #/ELA # (Marks)		
			Performance		Viva-Voce (...%)
			PRA (...%)	PDA (...%)	
1.	Determine the strength of materials used in drones frame.	CO-2	60	30	10
2.	Determine the strength of materials used in drones Propellers.	CO-2	60	30	10
3.	Test different parameters of batteries used in drones	CO-2	50	40	10
4.	Test motors suitable for specific Drone application.	CO-2	50	40	10
5.	Test and measure Gyro sensor and Accelerometer and their characteristics.	CO-2	50	40	10
6.	Test different sensors and their characteristics with Microcontroller based Flight controller board.	CO-2, CO-3	50	40	10
7.	Determine thrust/torque of motor by changing different drone motion	CO-2, CO-3	60	30	10

S.No	Laboratory Practical Titles	Relevant COs Number(s)	PLA #/ELA # (Marks)		
			Performance		Viva-Voce (…%)
			PRA (…%)	PDA (…%)	
8.	Test and troubleshoot Flight control board (FCB).	CO-3	60	30	10
9.	Test and perform communication of Flight control board (FCB) with sensor	CO-3, CO-2	60	30	10
10.	Test and perform communication of Flight control board (FCB) with motor.	CO-3, CO-2	60	30	10
11.	Test and perform communication of Flight control board with ESC.	CO-3	60	30	10
12.	Test and perform communication of Flight control board with RF transceiver.	CO-3	60	30	10
13.	Test Hardware assembly for drone.	CO-4 CO-3	50	40	10
14.	Perform different motion in drone simulator.	CO-4	50	40	10
15.	Build and run loops and decision statements for specific application in Python.	CO-5	50	40	10
16.	Build and Run functions for specific application and pass arguments in Python.	CO-5	50	40	10
17.	Write basic programming in python to interface different component of Drones.	CO-5, CO-3	50	40	10

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Instructional/Implementation Strategies: Different Instructional/ImplementationStrategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Field Trips, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology(ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources(OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	Drone Frame	Tricopter/Quadcopter/Hexacopter	1-13
2.	Propellers	10X4.5 CW/Others	1-13
3.	Speed Sensor	3.3 or 5.0Vdc	1-13
4.	Distance Sensor	5Volt operating voltage	1-13
5.	Gyro sensor and Accelerometer	5Volt operating voltage	1-13
6.	Barometer	Altitude tracking, temp range from 25°C to 40°C	1-13

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
7.	TOF Sensor	Accurate ranging up to 4 m, Fast ranging frequency up to 50	1-13
8.	Battery	Lithium Polymer Battery,2200mAH/others	1-13
9.	Motor	BLDC,1000kv or 1000RPM/volt	1-13
10.	Electronic speed Controller (ESC)	30 Amp,2-4s or cell	1-13
11.	Flight Controller Unit	KK 2.1.5/ ArdupilotAPM 2.8/ Pixhawk/others	1-13
12.	Transmitter and Receiver for radio signal	4 channels/6 Channels, 2.4 GHz & 5.8 GHz	1-13
13.	Drone Simulator Software	RC flight simulator	14
14.	Python Software	Hardware required-More than 4 GB RAM, 64 bit CPU preferable	15,16,17

R) Suggested Learning Resources:

(a) Suggested Books :

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Make: Getting Started with Drones: Build and Customize Your Own Quadcopter	Terry Kilby&Belinda Kilby	Shroff/Maker Media, First edition 2016, ISBN-978-9352133147
2.	Agricultural Drones: A Peaceful Pursuit	K R Krishna	Apple Academic Press,1st edition 2018, ISBN-978-1771885959
3.	DIY Drone and Quadcopter Projects: A Collection of Drone-Based Essays, Tutorials, and Projects	Editors Of Make	Shroff/Maker Media; First edition 2016, ISBN-978-9352133994
4.	Building Multicopter Video Drones: Build and fly multicopter drones to gather breathtaking video footage	Ty Audronis	Packt Publishing Limited; Illustrated edition,2014,ISBN-978-1782175438
5.	The Complete Guide to Drones	Adam Juniper	Ilex Press, Extended 2nd Edition,2018 ISBN-9781781575383

(b) Suggested Open Educational Resources (OER):

1. https://nptel.ac.in/courses/101104073
2. https://en.wikipedia.org/wiki/Unmanned_aerial_vehicle
3. https://www.scienceabc.com/innovation/what-is-drone-technology.html
4. https://www.dronezon.com/learn-about-drones-quadcopters/what-is-drone-technology-or-how-does-drone-technology-work/
5. https://www.youtube.com/watch?v=OWaXIK9sHeE
6. https://books.google.co.in/books?id=2M0hEAAAQBAJ&printsec=copyright&redir_esc=y#v=onepage&q&f=false

Note: Teachers are requested to check the creative commons licence status/ financial implications of the suggested OER, before use by the students.

(c) Others: (If any)

1. Learning Packages
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

S) Course Curriculum Development Team(NITTTR)

- Dr. K. K. Jain (Coordinator)
- Dr. Sanjeet Kumar (Co-coordinator)

******

A)	**Course Code**	:	**2000505E / 2000508E / 2000511E**
B)	**Course Title**	:	3D Printing and Design (Basics)
C)	**Pre- requisite Course(s)**	:	Computer aided Modeling
D)	**Rationale**	:	

Additive manufacturing (AM) or Additive layer manufacturing (ALM) is the industrial production name for 3D Printing. 3D Printing is a process that makes solid objects from a digital model. It involves depositing material either metal, powdered plastic, or liquid in thin layers (2D) to get a 3D object. This basic course on 3D Printing tries to develop understanding of the process of making real object from digital model in the students. It also covers the software/hardware required, various materials used for 3D Printing and details about printing process parameters. The knowledge gained through this course will help the students to take up advanced course on 3D Printing in next semester.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

- **CO-1** Develop CAD models for 3D Printing.
- **CO-2** Import and Export CAD data in .STL file format to generate GCODE file.
- **CO-3** Select suitable 3D Printing material for given applications.
- **CO-4** Select suitable 3D Printing process for given situations.
- **CO-5** Produce products using most popular FDM/SLA/SLS 3D Printing processes.

F) Course Articulation Matrix:

Course Outcomes (COs)	**Programme Outcomes (POs)**							**Programme Specific Outcomes (PSOs)** (if any)		
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**	**PSO-3**
CO-1	3	-	3	2	-	-	2			
CO-2	3	2	-	2	-	-	-			
CO-3	3	3	-	2	3	-	-			
CO-4	3	3	-	2	-	-	-			
CO-5	3	-	3	3	-	3	2			

Legend: High (3), Medium (2), Low (1) and No mapping (-)

G) Scheme of Studies:

CourseCode	**Course Title**	**Scheme of Studies (Hours/Week)**					
		Classroom Instruction (CI)		**Lab Instruction (LI)**	**Notional Hours (SW+ SL)**	**Total Hours (CI+LI+SW+SL)**	**Total Credits(C)**
		L	**T**				
2000505E / 2000508E / 2000511E	3D Printing and Design (Basics)	02	-	04	02	08	05

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI : Laboratory Instruction (Includes experiments/practical performances in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

SW: Sessional Work/Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, open educational resources (OERs)

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: SW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Scheme of Assessment:

Course Code	Course Title	Scheme of Assessment (Marks)						Total Marks (TA+SWA+LA)
		Theory Assessment (TA)		Sessional Work Assessment (SWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Sessional Work Assessment (PSWA)	End Sessional Work Assessment (ESWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2000505E / 2000508E / 2000511E	3D Printing and Design (Basics)	30	70	**20**	**30**	20	30	200

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

SWA: Sessional Work/Term work & Self Learning Assessment (Includes assessment related to student performance in self learning, assignments, Seminars, micro projects, industrial visits, any other student activities etc.

Note: Separate passing is must for progressive and end semester assessment for both theory and practical.

I) Course Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: [2000505E]

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain CAD-CAM and related terminologies. *TSO 1b.* Convert the given CAD file format into others. *TSO 1c.* Transfer the given CAD data to CAM facilities. *TSO 1d.* Classify 3D Printing processes. *TSO 1e.* List the advantages of additive manufacturing processes over	**Unit-1.0 Additive Manufacturing Introduction and CAD** CAD-CAM and its integration CAD- Part and Surface modeling CAD file formats Additive v/s Conventional Manufacturing processes Process chain for 3D Printing Classification of 3D Printing Processes Product design and prototyping	CO1

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
conventional manufacturing processes. *TSO 1f.* List typical steps involved in 3D printing of an object from digital model. *TSO 1g.* Explain reverse engineering steps for 3D Printing.	1.8 Reverse Engineering for 3D Printing	
TSO 2a. Explain the given STL interface terminology. *TSO 2b.* Use the given alternative 3D printing interface. *TSO 2c.* Generate STL file for the given CAD file. *TSO 2d.* Repair the given STL file. *TSO 2e.* Apply part orientation and support techniques for the given situation. *TSO 2f.* Perform slicing of the given CAD model using the given slicing software. *TSO 2g.* Generate tool path using simulation software for the given situation.	**Unit-2.0 Data Preparation for 3D Printing** STL interface Specification, STL data generation, STL data Manipulation, Advantages and limitations of STL file format, Open files, Repair of STL files, Alternative 3D Printing interfaces Part orientation and support generation, Factors affecting part orientation, Various models for part orientation determination, The function of part supports, Support structure design, Automatic support structure generation Model Slicing and Contour Data organization, Direct and adaptive slicing:Identification of peak features, Adaptivelayer thickness determination Tool path generation	CO1, CO2
TSO 3a. Explain the given 3D Printing processe. *TSO 3b.* List process parameters of the given 3D Printing processes. *TSO 3c.* Select 3D Printing materials for the given application. *TSO 3d.* Select 3D Printing processes among FDM, SLS, SLA for given application with justification.	**Unit-3.0 Additive Manufacturing Techniques** Stereo- Lithography, LOM, FDM, SLS, SLM, Binder Jet technology, Direct Energy Deposition Process parameter, Process Selection for various applications 3D Printing materials and selection Comparison between FDM, SLS, SLA	CO3, CO4
TSO 4a. Identify various Aerospace, Electronics, Health care, Automotive, Construction, Food processing, Machine tool components that can be 3D Printed. *TSO 4b.* Estimate the cost and time of 3D printing of the given component.	**Unit-4.0 Application of 3D Printing** 4.1 Additive Manufacturing Application Domains: Aerospace, Electronics, Health Care, Defense, Automotive, Construction, Food Processing, Machine Tools	CO3, CO4
TSO 5a. Select suitable 3D Printer and software for the given application with justification. *TSO 5b.* Analyze the effect of given 3D printing process parameters using 3D printer software simulation. *TSO 5c.* List steps to perform 3D scanning of the given object.	**Unit-5.0 3D Printers and Software and Scanners** Construction details and working of established 3D printers for plastics parts only: Stereolithography (SLA), Selective Laser Sintering (SLS), and Fused DepositionModeling (FDM). Accuracy, Precision and Tolerance in 3D printing. 3D Printer software- Fusion 360,	CO4, CO5

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 5d. Repair 3D scanned digital model. *TSO 5e.* Set different 3D printing process parameters to get a sound plastic component.	Solidworks, Onshape, Tinkercad, Ultimaker Cura, MeshLab, Simplyfy 3D, Repetier host, Slic3r, etc. – use and operation of anyone. 3D Scanners and working. Producing a part using FDM, SLA and SLS 3D Printer	

Note: One major TSO may require more than one Theory session/Period.

K) Laboratory (Practical) Session Outcomes (LSOs) and List of Practical [2000508E]

Practical/Lab Session Outcomes(LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1. Use CAD software. *LSO 1.2.* Prepare digital models of simple 3D entities.	1.	Develop digital models of following simple components using any CAD software: • Nut • Bolt • Network cable Jack • Coat button • Spoon	CO1
LSO 2.1. Prepare digital models of complex 3D entities and assemblies.	2.	Develop digital models of following assemblies using any CAD software: • Connecting Rod • Piston • Electric switch • Bathroom Tap • Mouse	CO1
LSO 3.1. Surf web for downloading readymade free CAD models. *LSO 3.2.* Convert one CAD file format into another.	3.	Download three digital CAD models freely available on web in different formats and then convert them into .stl/obj format.	CO1
LSO 4.1. Use the given Slicing software for 3D Printing. *LSO 4.2.* Perform slicing operation on the given digital model.	4.	Perform slicing operation on one digital model available under each Pr. No.1, 2 and 3.	CO2
LSO 5.1. Use the available 3D printing software. *LSO 5.2.* Selection of 3D printing process and performance parameters.	5.	Analyse the effect of different process parameters, materials on printing time, material required, surface finish, etc. through simulation using 3D printing software on sliced models available from Pr. No. 4	CO3, CO4, CO5
LSO 6.1. Produce single plastic components using available 3D printer. *LSO 6.2.* Perform post processing operations on printed component.	6.	Print one single component on available 3D printer with PLA/ABS material	CO3, CO4, CO5
LSO 7.1. Select appropriate layer thickness, tolerance, fit. *LSO 7.2.* Produce an assembly of plastic	7.	Print one assembly on available 3D printer with PLA/ABS material	CO3, CO4, CO5

Practical/Lab Session Outcomes(LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
components using available 3D printer.			
LSO 8.1. Choose suitable material for printing flexible structure (assembly of same small pieces to give flexible fabric effect). *LSO 8.2.* Choose suitable design/shape to create a flexible type structure. *LSO 8.3.* Produce flexible plastic structure using available 3D printer.	8.	Model and print a flexible fabric structure with PLA/ABS material (assembly of same small pieces to give flexible fabric effect)	CO3, CO4, CO5
LSO 9.1. Selection of 3D printing process parameters.	9.	Change printing process parameters and repeat experiment number 6.	CO4, CO5
LSO 10.1. Use of available 3D scanner. *LSO 10.2.* Develop 3D digital model using scanning approach. *LSO 10.3.* Modeling of complex 3D objects using 3D scanning.	10.	Scan the given complex component using available 3D Scanner.	CO5
LSO 11.1. Produce a complex plastic structure using available 3D printer and scanner. *LSO 11.2.* Apply Reverse Engineering approach to exactly 3D print an existing real object.	11.	Print the 3D scanned digital model of Pr. No. 10 on available 3D printer with PLA/ABS material	CO5

L) Sessional Work/Term Work and Self Learning: [2000511E]

a. **Assignments**: Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

b. **Micro Projects:**

1. Perform 3D printing of plastic casing of inhaler used by Asthma patients and estimate the cost.
2. Download 5 videos on 3D printing of different components, watch them and write a report to detail out the steps involved, 3D Printer used, 3D Printing software used, material used, complexity involved, printing time, post processing steps used.
3. Print two pieces of same components using ABS and PLA and compare their strength, surface roughness, weight, cost.
4. Download two 3D printing free software and try to check their compatibility with your lab printer.

c. **Other Activities:**

1. Seminar Topics:
    - Commercially available 3D printers and software.
    - Strength of 3D printed Plastic components as compared to Die cast Plastic components.
    - Properties of PLA and ABS 3D printing materials.
    - Reverse engineering application of 3D Printing.
2. Visits: Visit nearby tool room/industry with 3D Printing facilities. Prepare report of visit with special comments of 3D printing technique used, material used, single component/batch production/mass production and cost of printed component.

3. Self learning topics:
   - 3D printing of flexible plastic components.
   - 3D printing of micro/mini components.
   - Conversion of CAD file formats into IGES.
   - 3D scanning process.

M) Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and sessional work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		**Sessional Work Assessment (SWA)**			**Lab Assessment (LA)#**	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	**End Theory Assessment (ETA)**	**Sessional Work & Self Learning Assessment**			**Progressive Lab Assessment (PLA)**	**End Laboratory Assessment (ELA)**
			Assignments	**Micro Projects**	**Other Activities***		
CO-1	15%	10%	15%	-	-	20%	20%
CO-2	10%	20%	10%	25%	-	10%	20%
CO-3	15%	20%	15%	25%	33%	15%	20%
CO-4	30%	20%	30%	25%	33%	15%	20%
CO-5	30%	30%	30%	25%	34%	40%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

***** : Other Activities include self learning, seminar, visits, surveys, product development, software development etc.

****** : Mentioned under point- (N)

\# : Mentioned under point-(O)

Note: For CO attainment calculation Indirect assessment tools like Course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Specification Table for End Semester Theory Assessment: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and sessional work for ensuring CO attainment. The response/performance of the student in each of these designed activities is to be assessed to calculate CO attainment.

Unit Title and Number	Relevant COs Number(s)	Total Marks	ETA (Marks)		
			Remember (R)	**Understanding (U)**	**Application & above (A)**
Unit-1.0 Additive Manufacturing Introduction and CAD	CO1	12	4	3	5
Unit-2.0 Data Preparation for 3D Printing	CO1, CO2	10	4	2	4
Unit-3.0 Additive Manufacturing Techniques	CO3, CO4	19	5	5	9
Unit-4.0 Application of 3D Printing	CO3, CO4	10	2	3	5
Unit-5.0 3D Printers and Software and Scanners	CO4, CO5	19	5	5	9
	Total Marks	**70**	**20**	**18**	**32**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Specification Table for Laboratory (Practical) Assessment:

SN	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA (%)	PDA (%)	
1.	Develop digital models of following simple components using any CAD software: • Nut • Bolt • Network cable Jack • Coat button • Spoon	CO1	30	60	10
2.	Develop digital models of following assemblies using any CAD software: • Connecting Rod • Piston • Electric switch • Bathroom Tap • Mouse	CO1	40	50	10
3.	Download three digital CAD models freely available on web in different formats and then convert them into .stl/obj format.	CO1	30	60	10
4.	Perform slicing operation on one digital model available under each Pr. No.1, 2 and 3.	CO2	30	60	10
5.	Analyse the effect of different process parameters, materials on printing time, material required, surface finish, etc. through simulation using 3D printing software on sliced models available from Pr. No. 4	CO3, CO4, CO5	30	60	10
6.	Print one single component on available 3D printer with PLA/ABS material	CO3, CO4, CO5	30	60	10
7.	Print one assembly on available 3D printer with PLA/ABS material	CO3, CO4, CO5	30	60	10
8.	Model and print a flexible fabric structure with PLA/ABS material (assembly of same small pieces to give flexible fabric effect)	CO3, CO4, CO5	40	50	10
9.	Change printing process parameters and repeat experiment number 6.	CO4, CO5	40	50	10
10.	Scan the given complex component using available 3D Sanner.	CO5	40	50	10
11.	Print the 3D scanned digital model of Pr. No. 10 on available 3D printer with PLA/ABS material	CO5	30	60	10

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Instructional/Implementation Strategies: Different Instructional/ ImplementationStrategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources(OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	High end computers	Processor Intel Core i7 with Open GL Graphics Card, RAM 32 GB, DDR3/DDR4, HDD 500 GB, Graphics Card NVIDIA OpenGL 4 GB, OS Windows 10	All
2.	Parametric Computer Aided Design software	CATIA/Solid works/NX/Creo **OR** Available with CoE	1,2
3.	3D printer	Fused Deposition Modelling system with complete accessories; Build Volume-300 x 300 x 300mm or Higher; Layer Thickness-0.1 – 0.4 **OR** Available with CoE	6, 7, 8, 10
4.	3D Printing Material	ABS/PLA **OR** Available with CoE	6, 7, 8, 10
5.	3D Printing software	Latest version of software like: Cura/PrusaSlicer/ideaMaker/Meshmixer/MeshLab **OR** Available with CoE	3,4
6.	Post processing equipments and tools	Deburring tools (tool handle & deburring blades), Electronic Digital Caliper, Cleaning Needles, Art knife set, Long nose pliers, Flush cutters, Wire brush, Nozzle cleaning kit, Tube cutter, Print removal spatula, Needle file, Cutting mat, Glue stick, Wire stripper etc.	6, 7, 8, 10
7.	3D Scanner and Processing software	Handheld 3D scanner, Accuracy up to 0.1 mm, Resolution up to 0.2 mm, Real time onscreen 3D model projection and processing, Wireless technology with an inbuilt touch screen and battery, Extended field of view for capturing both large and small objects, Processing Software **OR** Available with CoE	10

R) Suggested Learning Resources:

(a) Suggested Books :

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing	Lan Gibson, David W. Rosen, Brent Stucker	Springer, 2010 ISBN: 9781493921133
2.	Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing	Andreas Gebhardt,	Hanser Publisher, 2011 ISBN: 156990507X, 9781569905074

3.	3D Printing and Design	Sabrie Soloman	Khanna Publishing House, Delhi ISBN: 9789386173768
4.	3D Printing and Rapid Prototyping- Principles and Applications	C.K. Chua, Kah Fai Leong	World Scientific, 2017 ISBN: 9789813146754
5.	Getting Started with 3D Printing: A Hands-on Guide to the Hardware, Software, and Services Behind the New Manufacturing Revolution	Liza Wallach Kloski, Nick Kloski	Make Community, LLC; 2nd edition, 2021 ISBN: 9781680450200
6.	Laser-Induced Materials and Processes for Rapid Prototyping	L. Lu, J. Fuh, Y.S. Wong	Kulwer Academic Press, 2001 ISBN: 9781461514695

(b) Suggested Open Educational Resources (OER):

1. https://onlinecourses.nptel.ac.in/noc21_me115/preview
2. https://archive.nptel.ac.in/courses/112/104/112104265/
3. https://www.youtube.com/watch?v=b2Od4YHcLAQ
4. https://www.youtube.com/watch?v=EF8CNR-gcXo
5. https://www.academia.edu/41439870/Education_Resources_for_3D_Printing
6. https://www.think3d.in/landing-pages/beginners-guide-to-3d-printing.pdf
7. https://all3dp.com/1/types-of-3d-printers-3d-printing-technology/

Note: Teachers are requested to check the creative commons licence status/ financial implications of the suggested OER, before use by the students.

(c) Others: (If any)

1. 3D Printing Projects DK Children; Illustrated edition, 2017
2. The 3D Printing Handbook: Technologies, design and applications Ben Redwood, Filemon Schöffer, Brian Garret, 3D Hubs; 1st edition, 2017
3. 3D Printer Users' Guide
4. 3D Printer Material Handbook
5. Lab Manuals

S) Course Curriculum Development Team(NITTTR)

- Dr. Sharad Pradhan(Coordinator)
- Dr. A. K. Sarathe(Co-coordinator)

******

A)	**Course Code**	**: 2000505 F / 2000508 F /2000511F**
B)	**Course Title**	**: Industrial Automation (Basic)**
C)	**Pre- requisite Course(s)**	**: Basic Mechanical Engineering, Basic Electrical Engineering, Digital Electronics and Basic programming skills**
D)	**Rationale**	**:**

The technological education and research scenario, all over the world, is turning towards a multidisciplinary one. The present scenario is different as compared to the recent past in the sense that the engineering disciplines are now dilating instead of diverging. The primary reason being that the current technological designs are of highly complex and inter-interdisciplinary nature involving synergistic integration of many aspects of engineering knowledge base**.** Industrial automation has become an essential part of every modern industry. Automation helps industry to increase the productivity, quality, accuracy and precision of industrial processes. Stiff competition, higher quality standards and growing concerns of safety & environmental damage have pushed the Industrial sector to adapt state-of-the-art Automation Techniques for effective utilization of resources and optimized performance of the plants. Today engineer is needed to meet the requirements of designing appropriate automation systems. They should have the knowledge of different fields like PLC and PID based Controller, Instrumentation, Networking, Industrial Drives, SCADA/HMI, High speed data acquisition, etc., to become a successful automation engineer. The discipline Automation is enormous in magnitude. The students passing this course will gain basic understanding about industrial automation and will be prepared to take up the advance course in Industrial automation in next semester**.**

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/laboratory/workshop/field/ industry.

After completion of the course, the students will be able to-

CO-1 Apply principles and strategies for automation for a given situation.

CO-2 Use sensors and input devices as per given situation.

CO-3 Test the given PLC for its functionality.

CO-4 Use actuators and output devices as per given situation.

CO-5 Test the working of various types of control system and controllers

F) Suggested Course Articulation Matrix:

Course Outcomes (COs)	**Programme Outcomes (POs)**							**Programme Specific Outcomes (PSOs)** (if any)		
	PO-1 Basic and Discipline Specific Knowledge	**PO-2**Proble m Analysis	**PO-3**Design/Dev elopment of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**	**PSO-3**
CO-1 Apply principles and strategies for automation for a given situation	3	2	-	2	2	-	2			
CO-2 Use sensors and input devices as per	3	2		2			2			

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes (PSOs) (if any)		
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**	**PSO-3**
the requirement.			2		-	-				
CO-3 Test the given PLC for its functionality.	3	2	2	2	2	-	2			
CO-4 Use actuators and output devices a per given situation**.**	3	2	2	2	2	-	2			
CO-5 Test the functionality of various types of control system and controllers	3	2	2	2	-	-	2			

Legend: High (3), Medium (2), Low (1) andNo mapping (-)

G) Scheme of Studies:

CourseCode	**Course Title**	**Scheme of Studies (Hours/Week)**					
		Classroom Instruction (CI)		**Lab Instruction (LI)**	**Notional Hours (SW+ SL)**	**Total Hours (CI+LI+SW+SL)**	**Total Credits(C) (CI+LI+SW+SL)**
		L	**T**				
2000505 F / 2000508 F/ 2000511F	Industrial Automation (Basic)	02	-	04	02	08	05

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction(Includes experiments/practical performances in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours:Hours of engagement by learners, other than the contact hours for ensuring learning.

SW: Sessional Work (includesassignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCS,spoken tutorials, open educational resources (OERs)

C: Credits.

Note: SW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Scheme of Assessment:

Course Code	Course Title	Scheme of Assessment (Marks)						Total Marks (TA+SWA+LA)
		Theory Assessment (TA)		Sessional Work Assessment (SWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Sessional Work Assessment (PSWA)	End Sessional Work Assessment (ESWA)	Progressive Lab Assessment(PLA)	End Laboratory Assessment (ELA)	
2000505F / 2000508F /2000511F	Industrial Automation (Basics)	30	70	20	30	20	30	200

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

SWA: Sessional Work/ Term work& Self Learning Assessment (Includes assessment related to student performance in selflearning, assignments, Seminars, micro projects, industrial visits, any other student activities etc.

Note: Separate passing is must for progressive and end semester assessment for both theory and practical.

Theory: 100 marks
Practical 50 marks

I) Course Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes(LSOs) leading to attainmentof Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Indian Knowledge System (IKS) and others need to be integrated.

J) Theory Session Outcomes (TSOs) and Units: [2000505 F]

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.1.a Describe Industry 4.0 and its component TSO.1.b Explain different types of automation systems TSO.1.c Identify the type of automation used in a given industry TSO.1.d Analyze the working of industrial processes and products for automation. TSO.1.e Select principles and strategies for automation for a given situation using 4R's and 1U TSO.1.f Select criteria for factory automation and processes automation for a given industry. TSO.1.g Describe briefly different systems used for industrial automation. TSO.1.h Describe IOT, IIOT and role of robots with respect to automation.	**Unit-1.0OverviewofIndustrial Automation** Introduction to Industry 4.0 and its components, Issues and challenges in automation Need of automation in industries, Principles and strategies of automation, factory automation, process automation Basic elements of an automated system, Structure of Industrial Automation Advanced automation functions, Levels of automations Industrial control Systems- Process and Discrete system Types of automation system: Fixed, Programmable, Flexible Integrated Automation and its application Different systems used for Industrial automation: PLC, HMI, SCADA, DCS, Drives. Introduction to Internet of Things (IoT) and Industrial Internet of Things (IIOT) and its application in Automation. Role of robots in automation and its components.	CO1 Apply principles and strategies for automation for a given situation.
TSO.2.a Explain PLC and list its advantages over relay systems. TSO.2.b Distinguish between PLC and a PC, PLC and dedicated controllers. TSO.2.c List the types of PLCs and brands available in the market. TSO.2.d Describe the function of each block of a PLC with the help of a block diagram. TSO.2.e Describe the basic sequence of operation of a PLC with a simple example. TSO.2.f Explain different PLC programming languages with simple examples. TSO.2.g Describe a simple PLC programming using ladder logic specifying I/O addressing TSO.2.h List the applications of PLC	**Unit-2.0Fundamentals of PLC** Introduction to PLC, evolution of PLC • Comparison of PLC and Personal Computer (PC) • Comparison of PLC and dedicated controllers like PAC and CNC • Types of PLC – Fixed, Modular and their types • Different brands of PLCs available in the market Building blocks of PLC -CPU, Memory organization, Input-Output modules (Discreteand Analog) Specialty I/O Modules, Power supply PLC programming languages with simple examples: • Functional Block Diagram (FBD), • Instruction List. • Structured text, • Sequential Function Chart (SFC), • Ladder Programming PLC I/O addressing in ladder logic Simple programming example using ladder logic Applications of PLC: Traffic light control, Elevator control, Motor sequencing control, Tank level control, temperature control, Conveyor system	CO2 Use sensors and input devices as per given situation.

Major Theory Session Outcomes (TSOs)	Unit s	Relevant COs Number(s)
	control	
TSO.3.a Identify the commonly used input field devices in PLC installations along with their symbols. TSO.3.b Draw symbol of various switches used in PLC installations describing the function of each switch. TSO.3.c Identify the various digital input devices used in a PLC installation. TSO.3.d Identify the commonly used sensors as input field devices found in PLC installations. TSO.3.e Describe the working of different types of discrete sensors giving their applications. TSO.3.f Describe the working of different types of advanced sensors giving their applications. TSO.3.g Select Sensors as per the given requirement for ecofriendly automation	**Unit 3 – Sensors and Input field devices** Analog input devices-Electromagnetic relays, Contactors, Motor starters, Manually operated Switches Toggle switch, pushbutton switch, knife switch andselector switches Mechanically operated switches, Limit switch, Temperature switch (Thermostat), Pressure switch, Level switch and their symbols Discrete/Digital Input device, Construction and working of Sensors • Proximity sensors- Inductive, Capacitive,Optical and ultrasonic Advanced sensors- Construction and workingof • Temperature sensors- Thermistor,Thermocouple and Resistance temperature Detector (RTD) • Liquid level sensor -Capacitive andUltrasonic • Force -Strain/Weight sensors • Flow sensors – turbine flow sensor • Pressure sensors- Linear VariableDifferential Transformer (LVDT) • Inclination sensor -Inclinometer • Acceleration sensor- Accelerometer • Angular and linear position sensor	**CO 3** Test the given PLC forits functionality
TSO.4.a Classify the actuators. TSO.4.b Describe the construction and working of a given actuator. TSO.4.c Explain the basic principle of operation of a given actuator. TSO.4.d Differentiate between hydraulic and pneumatic actuators TSO.4.e Explain the basic principle of operation of a given control valve. TSO.4.f Select actuators and valves as per the given requirement for ecofriendly automation. TSO.4.g Develop different hydraulic and pneumatic circuits for simple application. TSO.4.h Identify the commonly used output field devices in PLC installations TSO.4.i Draw the symbol of various output devices used in PLC installations describing the function of each. TSO.4.j Select output devices for a PLC installation as per the	**Unit 4- Actuators and output devices** Introduction to actuators, Classification of actuators Mechanical actuators -Translational and rotational motion, kinematic chains,cams, gears, belt and chain drives, bearings Hydraulic and Pneumatic actuators- linear and rotary actuators, single and double acting cylinder, directional, process and pressure control valves Electrical actuators • Electromechanical actuators Construction, working and application of Stepper motors, AC/DC Servo motors, BLDC Motor (Very brief) • Electrohydraulic actuators- Construction, working and application of Electro- hydrostatic actuator (EHA), ON/OFF Electro-hydraulic Rotary Actuator (E2H90, Control Valve Rotary Actuator (E2HR),Solenoid valve Thermal actuators **-**Construction, working and application ofHot-And-Cold-Arm Actuators, Chevron-Type Actuators	**CO 4** Use actuators and output devices as per given situation**.**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	4.6 Magnetic actuators- Construction, working principle and application of Moving coil actuators, moving magnet actuator, Moving iron actuator Selection criteria of actuators Other Output devices- Indicators, Alarms Pilot Lights, Buzzers, Valves, Motor starters, Horns and alarms, Stack lights Control relays,Pumps and Fans.	
TSO.5.a Describe the basic process control system with the help of a block diagram TSO.5.b Explain the types of control available in a process control TSO.5.c Describe the different types of controllers in a closed loop system with the help of a block diagram TSO.5.d Describe the construction, working and application of a given control system components.	**Unit 5– Control system** Block diagram of a basic control system Open and closed loop system, their transfer function First order and second order system and their output response and parameters Different types of inputs-step and ramp Types of control – On-off, Feed forward, Open loop and closed loop control and Transfer function Controllers in closed loop control • Proportional Controller(P Controller) • Integral Controller (I Controller) • Derivative controller (D- Controller) • P-I Controller • P-D Controller • PID Controller	**CO5** Test the working of various types of control system and controllers

K) Laboratory (Practical) Session Outcomes (LSOs) and List of Practical [2000508 F]

Practical/Lab Session Outcomes (LSOs)	S.No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSOs 1.1 Identify various building blocks and major automation components in a given robotic system LSOs 1.2 Identify various building blocks and major automation components in a given electrical drives	1.	Identify major automation components in a given system	**CO1**
LSOs 1.3 Analyze and plan the steps to automate the given system.	2.	Analyze given traditional machine in the laboratory for and identify the steps and components required to automate it.	
LSO 1.4. Identify the building blocks of a given typical SCADA system LSO 1.5. Identify the symbol library of SCADA software	3.	Use Scada software for simple application	
LSOs 2.1 Identify the various parts and front panel status indicators of the given PLC.	4.	Observe various parts and front panel indicators of a PLC	**CO2**

LSOs 2.2 Identify different input and output devices that can be connected to a given PLC.	5.	Observe different types of switches and their symbols sensors, lamp, alarm, motor, fan used in a PLC	
LSOs 2.3 Test the analog input and output lines of the given PLC.	6.	Identify Analog input and output lines of a PLC	
LSOs 2.4 Test the digital input and outlines of the given PLC.	7.	Identify digital input and output lines of a PLC	
LSOs 2.5 Use PLC to control the devices like Lamp, Alarm, motor using push button switches	8.	Practice using PLC to control various digital and analog output devices	
LSO 3.1. Test the response of digital inductive proximity sensorused to detectdifferent types of materials	9.	Identify different types of digital inductive proximity sensor and its use	**CO3**
LSO 3.2. Test the response of digital capacitive proximity sensors used to detect o different materials	10.	Identify different types of digital capacitive proximity sensor and its use	
LSO 3.3. Test the response of digital optical proximity sensor used to detect different materials	11.	Identify different types of digital optical proximity sensor and its use	
LSO 3.4. Test the response of digital ultrasonic proximity sensors used to detect different materials	12.	Identify different types of digital ultrasonic proximity sensor and its use	
LSO 3.5. Use thermistor to measure temperature of a given material	13.	Identify different types of thermistor and its use	
LSO 3.6. Use Thermocouple to measure the temperature of a given liquid and plot the output voltage versus temperature	14.	Observe the conversion of temperature to electric parameter conversion of a Thermocouple	
LSO 3.7. Use RTD to control the temperature of an oven	15.	Observe different types of RTDs used in industries for temperature measurement	
LSO 3.8. Use flow sensors to measure the flow of a given liquid or gas	16.	Observe different types of flow sensors used in industries for flow measurement	
LSO 3.9. Use pressure sensors to measure the pressure of a liquid or gas	17.	Observe different types of pressure sensors used in industries for pressure measurement	
LSO 3.10. Use load cell for measurement of mechanical force/weight.	18.	Observe the different types of load cell used in industries for force/weight measurement	

LSOs 4.1 Design and actuate pneumatic circuit for lift control LSOs 4.2 Design a pneumatic system that rivets the pockets on jeans LSOs 4.3 Design pneumatic circuit to open and close the security gate and control the speed. LSOs 4.4 Design a circuit for speed control of hydraulic motor meter out circuit by using 4/3 DC valve. LSOs 4.5 Design a circuit for speed control of double acting cylinder meter in by using 4/2 dc solenoid valve. LSOs 4.6 Designing a circuit for speed control of double acting cylinder meter out by using 4/3 solenoid valve	19.	Design and actuate pneumatic/ hydraulic circuit for the given situation	
LSOs 4.7 Direct acting of hydraulic motor	20.	Operate hydraulic motor	
LSOs 4.8 Operate stepper motor and control the motor by changing number of steps, the direction of rotation and speed.	21.	Operate stepper motor	
LSOs 4.9 Identify the components of thermal and magnetic actuators available in the laboratory. LSOs 4.10 Use thermal and magnetic actuators	22.	Thermal and magnetic actuators	
LSOs 5.1 Test the output response of a open loop closed loop and feed forward path	23.	Analyze the given system to study open loop, closed loop and feed forward path.	**CO5**
LSOs 5.2 Build and test the output response of a first order system for a step input using a CRO	24.	Analyze the given first order system and its transfer function and output response	
LSOs 5.3 Build and test the response of a second order system for a step input usingCRO.Also mark various parameters	25.	Analyze the given second order system and its transfer function and output response	
LSOs 5.4 Test the Output response of an on-off and Proportional control-based level control system.	26.	Analyze the given water level control system with on-off, Proportional control.	
LSOs 5.5 Test the Output response pf a P+I+D based level control system.	27.	Analyze the given water level control system with P+I+D control.	

L) Sessional Work and Self Learning: [2000511 F]

a. **Assignments**: Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

i. State three advantages of using programmed PLC timer over mechanical timing relay.
ii. Prepare a list of open source PLC software

iii. Prepare a list of open source SCADA software.
iv. List the practical applications of PLC systems
v. List the practical applications of SCADA systems.
vi. Compare the PLC and PC with regard to:
    - Physical hardware differences
    - Operating environment
    - Method of programming
    - Execution of program
vii. Prepare classification chart of different types of actuators.
viii. Differentiate between Nano and micro actuators.

b. Micro Projects:

1. Develop a relay-based motor control automation such that the motor reverses its direction when the limit switches are activated.
2. Develop a simulation to connect analog and digital input to the PLC.
3. Develop a simulation to connect analog and digital output to the PLC.
4. Develop a simple automatic water level controller using magnetic float switch.
5. Develop a simple automatic door system using optical sensor and linear actuator.
6. Troubleshoot the faulty equipment/kit available in automation laboratory
7. Select one industry and analyze the process and propose the automation strategies' that can be used for automation.
8. Develop a working model of a given application using given actuators and valves.

c. Other Activities:

1. Seminar Topics- PLC architecture, Different types of sensors, Industrial Applications of PLC and SCADA
2. Visits – Visit any industry with full or semi automation and prepare a report on type of automation used.
3. Surveys-Carry out a market/internet survey of PLC and prepare the comparative technicalspecifications of any one type of PLC (Micro or Mini) of different manufacturer.
4. Product Development- Develop a prototype automatic railway crossing system

Software Development- Download any open source software for PLC and install on your laptop/PC and carry out basic PLC programming

5. Surveys – carry out market survey for different types of electrical actuators available and prepare the comparative technical specifications of electrical actuators used in industries.
6. Visit industry and prepare a report on different types of hydraulic and pneumatic circuits used by the industry in the given section, components used, power requirement, output achieved and maintenance activities required.

d. Self-learning topics:

1. Use of PLC for different industrial applications
2. Use of sensors in commercial field
3. Use of sensors in home automation
4. Compare Specifications of PLCs of different manufacturers of any one type PLC

M) Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and sessional work for ensuring CO attainment. There sponse/performance of the student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Scheme of Assessment (Marks)								
	Theory Assessment (TA)					Lab Assessment (LA)			
	Progressive Theory Assessment (PTA)# Class/Mid Sem Test	End Theory Assessment (ETA)**	Sessional Work & Self Learning Assessment (SWA)			Progressive Lab Assessment (PLA)			End Laboratory Assessment (ELA)#
			Assignments(s)	Micro Projects	Other Activities*	Process Assessment (PRA)	Product Assessment (PDA)	Viva-Voce	
CO-1	15 %	20%	20 %	100	10 %	45%	35 %	100%	20 %
CO-2	20 %	20%	20 %		15 %	45%	35 %		20 %
CO-3	25 %	20%	20 %		15 %	45%	35 %		20 %
CO-4	25 %	20%	20 %		30 %	45%	35 %		20 %
CO-5	15 %	20%	20 %		30 %	45%	35 %		20 %
Total Marks	**20**	**70**	**4**	**4**	**2**	**8**	**8**	**4**	**30**

Legend:

*** :** Other Activities include seminar, visits, surveys, product development, software development etc.

****:** Mentioned under point- (N)

\# : Mentioned under point-(O)

Note: To calculate CO attainment 80% weightage of direct assessment tools and 20% of indirect assessment tools may be taken.

N) **Specification Table for End Semester Theory Assessment:** The course teacher has to decide and use appropriate assessment strategy and its weight age in theory, laboratory and sessional work for ensuring CO attainment. The response/performance of the student in each of these designed activities is to be assessed to calculate CO attainment.

Unit Title and Number	Relevant COs Number(s)	Total Marks	ETA (Marks)		
			Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Overview of Industrial Automation	**CO1**	12	4	6	4
Unit-2.0 Fundamentals of PLC	**CO2**	17	5	6	6
Unit-3.0 Sensors and Input field devices	**CO3**	16	4	6	6
Unit-4.0 Actuators and output devices	**CO4**	15	4	5	6
Unit- 5.0 Control system	**CO5**	10	3	4	4
Total Marks		**70**	**20**	**27**	**26**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) **Specification Table for Laboratory (Practical) Assessment:**

S.NO	Laboratory Practical Titles	Relevant COs Number(s)	PLA #/ELA # (Marks)		
			Performance		Viva-Voce (10 %)
			PRA (45%)	PDA (45%)	
1.	Identify major automation components in a given system	CO1	45 %	35 %	20%
2.	Analyze given traditional machine in the laboratory for and identify the steps and components required to automate it.	CO1	45 %	35 %	20%
3.	Use Scada software for simple application	CO1	45 %	35 %	20%
4.	Observe various parts and front panel indicators of a PLC	CO2	45 %	35 %	20%
5.	Observe different types of switches and their symbols sensors, lamp, alarm, motor, fan used in a PLC	CO2	45 %	35 %	20%
6.	Identify Analog input and output lines of a PLC	CO2	45 %	35 %	20%
7.	Identify digital input and output lines of a PLC	CO2	45 %	35 %	20%
8.	Practice using PLC to control various digital and analog output devices	CO2	45 %	35 %	20%
9.	Identify different types of digital inductive proximity sensor and its use	CO3	45 %	35 %	20%
10.	Identify different types of digital capacitive proximity sensor and its use	CO3	45 %	35 %	20%
11.	Identify different types of digital optical proximity sensor and its use	CO3	45 %	35 %	20%
12.	Identify different types of digital ultrasonic proximity sensor and its use	CO3	45 %	35 %	20%
13.	Identify different types of thermistor and its use	CO3	45 %	35 %	20%
14.	19. Observe the conversion of temperature to electric parameter conversion of a Thermocouple.	CO3	45 %	35 %	20%
15.	Observe different types of RTDs used in industries for temperature measurement	CO3	45 %	35 %	20%
16.	Observe different types of flow sensors used in industries for flow measurement	CO3	45 %	35 %	20%
17.	Observe different types of pressure sensors used in industries for pressure measurement	CO3	45 %	35 %	20%
18.	Observe the different types of load cell used in industries for force/weight measurement	CO3	45 %	35 %	20%
19.	Design and actuate pneumatic/ hydraulic circuit for the given situation	CO4	45 %	35 %	20%
20.	Operate hydraulic motor	CO4	45 %	35 %	20%
21.	Operate stepper motor	CO4	45 %	35 %	20%
22.	Thermal and magnetic actuators	CO4	45 %	35 %	20%
23.	Analyze the given system to study open loop, closed loop and feed forward path.	CO5	45 %	35 %	20%
24.	Analyze the given first order system and its	CO5	45 %	35 %	20%

S.NO	Laboratory Practical Titles	Relevant COs Number(s)	PLA#/ELA# (Marks)		
			Performance		Viva-Voce (10 %)
			PRA (45%)	PDA (45%)	
	transfer function and output response				
25.	Analyze the given second order system and its transfer function and output response	CO5	45 %	35 %	20%
26.	Analyze the given water level control system with on-off, Proportional control.	CO5	45 %	35 %	20%
27.	Analyze the given water level control system with P+I+D control.	CO5	45 %	35 %	20%

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubricsneed to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Field Trips, Portfolio Based, Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field Information and CommunicationsTechnology(ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Session, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	SCADA software (reputed make like Allen Bradley, Siemens etc.,)	Ready-to-use symbol library, React and respond in real-time, Real time monitoring, Friendly, manageable, secure, extensible, Easy-to-use, easy to implement, Easy configuration, simplified maintenance, Communication with PLC, easy and flexible alarm definition, data collection and analysis for new and existing systems, easy-to-use for report generation, open access to historical data, different packages available with input/output structure. Open source software SCADA software: like Ellipse/FTVSE/Wonderware/ open SCADA can also be used	3
2.	Universal PLC Training System with HMI (Of reputed make such as Allen bradely, Siemens, etc.,) Compatible with SCADA software	Human Machine Interface (HMI) display, PLC with 16 digital inputs, 16 digital outputs with RS232 communication facility. Open platform to explore wide PLC and HMI applications. Industrial look & feel. Toggle switches, push to ON switch, proximity sensor, visual indicator, audio indicator, and DC motor. Experiments configurable through patch board. Powerful instruction sets. Several sample ladder and HMI programs. PC based ladder and HMI programming. Extremely easy and student friendly software to develop different programs. Easy downloading of programs. Practice troubleshooting skills. Compact tabletop ergonomic design. Robust construction. PLC gateway for cloud connectivity. Open source software like Ladder logic simulator, Pico soft Simulator, Logixpro simulator, Simple EDA tools can also be used	4,5,6,7,8

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
3.	Proximity sensors kit	The kit should comprise of the following proximity sensor - Inductive Proximity Sensor, Capacitive Proximity Sensor, Magnetic Sensor, Optical Sensor, Audio and LED indicator for the object detection. Along with learning material	9,10,11,12
4.	Temperature transducer kit	Temperature Transducers Test Bench includes different types of temperature sensors including bimetallic strip, RTD, thermocouple, thermistor, RTD/thermocouple temperature display and thermistor, temperature display, heater, fan, switches and its indicator.Separate heater and fan chamber with stand. On panel digital voltmeter, digital ammeter, RTD/thermocouple temperature display, NTC temperature display, toggle switch for heater and fan with indicator, experiments configurable through patch board, heavy duty Test bench, castor wheel (with locking mechanism) is provided at legs of Test bench so that it can be easily moved, enhanced electrical safety consideration.	12,13,14
5.	Pressure transducer kit	Pressure transducer kit should include different types of pressure sensors including capacitive pressure transducer, load cell, bourdon tube pressure gauge, and pressure vessel.Pressure vessel with pressure gauge, safety valve, non returning valve bourdon gauge and capacitive transducer and air compressor, on panel digital voltmeter, digital ammeter, 4-20ma display, 0-10V DC display, toggle switch for compressor, load cell with suitable weight, experiments configurable through patch board, self -contained, bench-mounting arrangement, castor wheel (with locking mechanism) is provided at legs of Test bench so that it can be easily moved, enhanced electrical safety consideration. Detailed experiment manual should be supplied with the kit.	16
6.	Flow sensor kit	Turbine flow sensor kit	15
7.	Strain Gauge kit	The kit should provide study of Strain Gauge and their application for measurement of Strain. It should help to study bridge configuration of Strain Gauge and the signal conditioning circuits required to measure strain. It should use cantilever beam arrangement to produce strain on Strain Gauge.The Strain Gauges are firmly cemented to the cantilever at the point where the strain is to be measured. Weights are placed on free end of cantilever. Strain developed changes the resistance of Strain Gauge which is detected by full bridge configuration. It should comprise of Seven-segment LED display showing strain in micro strain units. Different weights should be provided to perform linearity and sensitivity experiments. Detailed experiment manual should be supplied with the kit. Test-points to observe input output of each block, onboard gain and offset null adjustment, built in DC Power Supplies, 3½ digits LED display, onboard Cantilever arrangement, high repeatability and reliability The kit should be capable of performing following experiments: • Measuring strain using strain gauges and cantilever assembly. • Determination of linear range of operation of strain measurement. • Determination sensitivity of the kit	17
8.	Cut sections of pumps, actuators, valves and	Suitably cut and mounted on a sturdy base to show the internal details.	18

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
	accessories used in hydraulic systems		
9.	Working models of pumps, actuators, valves and accessories used in hydraulic systems	Working models mounted on sturdy base to demonstrate the operation.	18
10.	Working models of pumps, actuators, valves and accessories used in pneumatic systems	Working models mounted on sturdy base to demonstrate the operation.	18
11. 8	Oil Hydraulic trainer	Mounted on sturdy base fitted with all standard units and accessories to create various hydraulic circuits. Hydraulic trainer with simulation software Pneumatic trainer with simulation software • Filter Regulator Combination with Lubricator (FRL Unit) with pressure gauge , Junction Box with slide valve, Push Button Valve , 3/2 NC Roller lever valve ,3/2 NC Roller lever valve ,5/2 Double external pilot operated valve, 5/2 External pilot operated valve with spring return , 5/2 Hand lever with spring return, 5/2 Hand lever valve with detent – for maintained pilot operation of a SAC , 5/2 Valve with Lever head, 5/2 Value with Mushroom head , Flow control valve – Metering IN & OUT , Shuttle Valve (OR valve) , Quick Exhaust Valve with Quick coupler plug • Double Acting Cylinder (DAC) with Quick coupler socket (with accessories: Screw driver – for cushioning adjustment), Single Acting Cylinder (SAC), Swivel fitting assembly with Quick coupler plug, Multi distributor fittings (for cascading circuit designing) • Single Solenoid Valve with Spring Return (with LED), Double Solenoid Valve (with LED), Magnetic Reed Switch, Magnetic Reed Switch, Relay Logic Unit – 2C/0-3 relays, Electrical Push Button Unit, Electrical Selector Switch Unit, Timer	18
12.	Pneumatic Trainer	Mounted on sturdy base fitted with all standard units and accessories to create various Pneumatic circuits. Pneumatic trainer with simulation software • Filter Regulator Combination with Lubricator (FRL Unit) with pressure gauge, Junction Box with slide valve • Push Button Valve, 3/2 NC Roller lever valve, 3/2 NC Roller lever valve, 5/2 Double external pilot operated valve (Memory valve) • 5/2 External pilot operated valve with spring return, 5/2 Hand lever with spring return, 5/2 Hand lever valve with detent, 5/2 Valve with Lever head ,5/2 Value with Mushroom head, Flow control valve, Shuttle Valve (OR valve), AND valve • Quick Exhaust Valve with Quick coupler plug, Double Acting Cylinder (DAC) with Quick coupler socket, Single Acting Cylinder (SAC), Swivel fitting assembly with Quick coupler plug • Aluminum Profile Table Top, Profile Table Top, Miniature Double Acting Cylinder (DAC), Single Solenoid Valve with Spring Return, Double Solenoid Valve (with LED) • Magnetic Reed Switch, Relay Logic Unit – 2C/0-3 relays, Electrical Push Button Unit, Electrical Selector Switch Unit (Black Selector – 1 no, Green Push Button – 1 no), Timer, Simulation software	18

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
13.	Advanced Electro - Hydraulic and Electro - Pneumatic Hardware systems with work stations and simulation software	• Electro - Hydraulic and Electro - Pneumatic Hardware systems with PLC and simulation software • Profile plate, Frame with Castor Wheels, Filter, Lubricator, Regulator with pressure gauge, Hand Slide Valve, Connection component set, Plastic Tubing, Power Supply & cables, Pressure Gauge, 3/2 Way double solenoid valve	18
14.	Output devices	Servomotor, DC motor, AC motor, stepper motor, Conveyer Belt control by PLC, water level control etc.	18,19,20
15.	Thermal actuators	Hot-And-Cold-Arm Actuators, Chevron-Type Actuators	21
16.	Magnetic actuators	Moving Coil Controllable Actuators, Moving Iron Controllable Actuator	21
17.	Open and closed loop control system kit	Open and closed loop system kit should be able to measure the output response using CRO	22
18.	First and second order control system	First and second order system with input and output terminals provision	23,24
19.	Process control system with feed forward path kit	Process control system with feed forward path kit with input and output terminals provision	22
20.	PID Controller Test Bench	PID Controller Test Bench is a complete setup to control process through two-point (on/off) and three-point (PID) controllers. Industrial PID controller with RS485 communication facility, Thermocouple temperature sensor, Float switch for detection of water level, Temperature measurement and control, User friendly software, USB Interface, Heavy duty Test bench, Electrical control panel, Leak proof sturdy piping and tanks, SS Sump tank for inlet and outlet of water, Enhanced electrical safety considerations, Caster wheel (with locking mechanism) at the legs of Testbench for easy movement.	25,26

R) Suggested Learning Resources:

(a) Suggested Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Introduction to Programmable Logic Controllers	Dunning, G.	Thomson /Delmar learning, New Delhi, 2005, ISBN13: 9781401884260
2.	Programmable Logic Controllers	Petruzella, F.D.	McGraw Hill India, New Delhi, 2010, ISBN: 9780071067386
3.	Programmable Logic Controllers	Hackworth, John; Hackworth, Federic	PHI Learning, New Delhi, 2003, ISBN: 9780130607188
4.	Industrial automation and Process control	Stenerson Jon	PHI Learning, New Delhi, 2003, ISBN: 9780130618900
5.	Programmable Logic Controller	Jadhav, V. R.	Khanna publishers, New Delhi, 2017, ISBN: 9788174092281
6.	Programmable Logic Controllers and Industrial Automation - An introduction,	Mitra, Madhuchandra; Sengupta, Samarjit,	Penram International Publication, 2015, ISBN: 9788187972174
7.	Control System	Nagrath & Gopal	New Age International Pvt Ltd, ISBN: 9789386070111, 9789386070111
8.	Linear Control Systems with MATLAB Applications, Publisher:	Manke, B. S.	Khanna Publishers, ISBN: 9788174093103, 9788174093103
9.	Supervisory Control and Data Acquisition	Boyar, S. A.	ISA Publication, USA, ISBN: 978-1936007097
10.	Practical SCADA for industry,	Bailey David ; Wright Edwin	Newnes (an imprint of Elsevier), UK 2003, ISBN:0750658053

(b) Suggested Open Educational Resources (OER):

1. Process Automation Control- online Tutorial: www.pacontrol.com
2. PLC product: www.seimens.com
3. www.ab.rockwellautomation.com
4. PLC product: www.abb.co.in
5. Different product of PLC and Peripherals, Smart Tile CPU Board, All in one lighting energycontroller, Classic PLC www.triplc.com
6. Simulation software:http://plc-training-rslogix-simulator.soft32.com/free-download/
7. Simulator :www.plcsimulator.net/
8. https://www.youtube.com/watch?v=y2eWdLk0-Ho&list=PLln3BHg93SQ_X5rPjqP8gLLxQnNSMHuj-
9. https://www.youtube.com/watch?v=86CrhxgAKTw

Note: Teachers are requested to check the creative commons licence status/ financial implications of the suggested OER, before use by the students.

(c) Others: (If any)

1. Learning Packages
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

S) Course Curriculum Development Team(NITTTR)

- Dr. Vandana Somkuwar(Coordinator)
- Dr. C. S. Rajeshwari(Co-coordinator)

****
**

A)	**Course Code**	:	**2000505G / 2000508G / 2000511G**
B)	**Course Title**	:	**Electric Vehicle (Basic)**
C)	**Prerequisite Course(s)**	:	
D)	**Rationale**	:	

Fossil fuel consumption and its adverse impact on the environment have led most nations in the world to adopt electric vehicles for mobility. Most automobile companies are switching from internal combustion engines to electric, a cleaner, and more sustainable alternative. But, in the present scenario, the automobile industries are facing a shortage of skilled technicians needed for the transition to electric drives as the primary source of motive power. There is a huge skill gap between industry and academia when it comes to the task of taking the entire automobile industry towards electric mobility. Therefore, this basic course on an electric vehicles is included in the curriculum of the diploma programme as an open elective course to fill this gap and gain a basic understanding of the importance and necessity of electric vehicles. This course tends to enable participants with multidisciplinary exposure and give them a brief idea about electric vehicles, and their importance. This course gives some basic technical foundations regarding electric vehicles to help them move on to advanced electric vehicle courses.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of the following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/laboratory/workshop/field/ industry.

After completion of the course, the student will be able to-

CO-1 Classify the EVs based on configurations.

CO-2 Identify relevant Motors for the given EV application.

CO-3 Test the performance of batteries used for EV applications.

CO-4 Distinguish between the EV Charging stations based on their Configurations.

CO-5 Follow regulatory requirements and policies for EV Industry.

F) **Course Articulation Matrix:**

Course Outcomes (COs)	**Programme Outcomes (POs)**							**Programme Specific Outcomes (PSOs)**(if any)		
	PO-1 Basic and Discipline-Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**	**PSO-3**
CO-1 Classify the EVs based on configurations	3	2	-	2	2	-	3			
CO-2 Identify relevant Motors for the given EV application.	3	2	2	2	2	1	3			
CO-3 Test the performance of batteries used	2	2	3	3	2	2	3			

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes (PSOs)(if any)		
	PO-1 Basic and Discipline-Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**	**PSO-3**
for EV applications										
CO-4 Distinguish between the EV Charging stations based on their configurations	2	2	1	2	2	1	2			
CO-5 Follow regulatory requirements and policies for EV Industry.	1	1	-	-	3	1	2			

Legend: High (3), Medium (2), Low (1) and No mapping (-)

G) Scheme of Studies:

CourseCode	Course Title	Scheme of Studies (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (SW+ SL)	Total Hours (CI+LI+SW+SL)	Total Credits(C)
		L	T				
2000505G / 2000508G / 2000511H	Electric Vehicles (Basic)	02	-	04	02	08	05

Legend:

CI: Classroom Instruction (Includes different instructional/ implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem-based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances in the laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

SW: Sessional Work/Term work (includes assignments, seminars, micro-projects, industrial visits, any other student activities, etc.)

SL: Self-Learning, MOOCs, Spoken Tutorials, Open Educational Resources (OERs)

C: Credits= (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: SW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of the teacher to ensure the outcome of learning.

H) Scheme of Assessment:

Course Code	Course Title	Scheme of Assessment (Marks)						Total Marks (TA+SWA+LA)
		Theory Assessment (TA)		Sessional Work Assessment (SWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Sessional Work Assessment (PSWA)	End Sessional Work Assessment (ESWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2000505G / 2000508G / 2000511G	Electric Vehicles (Basic)	30	70	20	30	20	30	200

Legend:

PTA: Progressive Theory Assessment in the classroom (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

SWA: Sessional Work/Term work& Self-Learning Assessment (Includes assessment related to student performance in self-learning, assignments, Seminars, micro-projects, industrial visits, any other student activities etc.

Note: Separate passing is a must for progressive and end-semester assessment for both theory and practical.

I) Course Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at the course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes(LSOs) leading to the attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020-related reforms like Green skills, Sustainability, Multidisciplinary aspects, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: [2000505G]

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Identify the types of the vehicle based on the physical features, specification data and information. TSO 1b. State the advantages of EVs over Conventional IC Engine Vehicles. TSO 1c. Identify different components of Electric Vehicle systems TSO 1d. Explain the functions of different components of the EV	**Unit-1.0Introduction to Electric Vehicle** Review of Conventional Vehicle Engine System Electric Vehicle (EV) • The necessity of Electric Vehicle • Types of Electric Vehicles - Plug-in hybrid - Battery electric vehicle - Hybrid electric vehicle - Fuel Cell Electric Vehicle • Advantages of Electric Vehicles Electric Vehicle Components: Motor, Motor Controller, Battery, Battery Management System, and Charging System.	CO1
TSO 2a. Explain the general characteristics of motors used in EV TSO 2b. List different types of motors used in EV TSO 2c. Explain the working principles of motors used in	**Unit-2.0 Electric Motors used in EVs** Electric Motors for EV applications • General Characteristics of motors • Types of Motors: DC, Brushless DC,	CO2

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
EV applications TSO 2d. Interpret the nameplate ratings of the motors for EV applications. TSO 2e. Explain the motor selection criteria for particular EV applications. TSO 2f. Describe the Mechanical and Electrical Connections of Motors.	Induction, Permanent Magnet Synchronous Motors, Switched Reluctance Motors Rating of Motors Selection Criteria Physical Location Connection of Motors: Mechanical Connections and Electrical Connections	
TSO 3a. List the batteries used in EVs for energy storage TSO 3b. State various parameters related to batteries used in EV applications. TSO 3c. Explain the charging and discharging process of the given batteries. TSO 3d. Explain the salient features of Lithium Ion batteries TSO 3e. Explain the Fuel Cell Storage System. TSO 3f. Identify various sensors installed for monitoring Battery condition. TSO 3g. Explain Battery Management System in EV using Block Diagram. TSO 3h. Describe the procedure of battery Disposal and Recycling	**Unit- 3.0 EV Batteries and Energy Storages** Types of Batteries: Lead Acid, Nickel Based, Lithium Based Battery Parameters Charging (AC) and Discharging(DC) Process Lithium Ion Batteries Fuel Cells, Fuel Cell Storage System Battery Condition Monitoring Battery Management System (BMS) • Need of BMS • Block Diagram of BMS Battery Disposal and Recycling	**CO3**
TSO 4a. Identify different types of diodes and transistors. TSO 4b. Describe the testing procedure for the given Diode and Transistor. TSO 4c. Explain the working principles of the given power electronic converter circuit. TSO 4d. Describe the types of Charging Systems TSO 4e. Describe different Components of the Charging System TSO 4f. Explain the working of the Charging System using a single-line diagram.	**Unit- 4.0 EV Charging Systems** Power electronics in EV • Power electronics components • Rectifiers • DC to DC Converter • DC to AC Converter Charging System • Types of charging Systems • Components of Charging Systems • Single line Diagram of Charging System	**CO4**
TSO 5a. Understand the Rules and Regulations set by the Government for selecting and manufacturing various components of an electric vehicle. TSO 5b. Understand the Policies for E-Vehicles. TSO 5c. Appreciate the importance of the reduction of greenhouse gases in the environment.	**Unit- 5.0 Regulatory Requirements and Policies for EV Industry** Rules and Regulations set by the Indian government for the designer/manufacturer of EVs. Policies in India Global Policies for E- Vehicles. Carbon Footprint Issues	**CO5**

Note: One major TSO may require more than one Theory session/Period.

K) Laboratory (Practical) Session Outcomes (LSOs) and List of Practical [2000508G]

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 2.1 Use the relevant digital meter for the given application. LSO 2.2 Use a measuring instrument for the given application. LSO 2.3 Use safety kits while working in the	1.	• Practice using digital meters such as AC, DC Clamp Meters, Digital Multimeters, Lux Meters, etc. • Practice using Screw Driver Kit, Vernier	CO1

Practical/Lab Session Outcomes (LSOs)		S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
	laboratory.		Caliper, Micrometer, Ampere Meter, Voltage Meter, and Techno-meter. • Practice using safety kits.	
LSO 2.1	Identify the motors used in EV applications	2.	• Identification of motors used in EVs	CO2
LSO 2.2	Identify the given motor terminals			
LSO 3.1	Identify the batteries available in the	3.	• Testing of Batteries used in EVs	CO3
	laboratory.			
LSO 3.2	Measure an open circuit voltage of the			
	given battery.			
LSO 3.3	Determine the Ampere -Hour Capacity of			
	the given battery with a given load.			
LSO 3.4	Test the performance of the given battery			
	with different charging rates and at			
	different ambient temperatures			
LSO 3.5	Demonstrate the effect on the state of			
	health of the battery after several charge/			
	discharge cycles.			
LSO 3.6	Evaluate the temperature cut-off point for		• Battery Management System	
	the given BMS.			
LSO 4.1	Identify the Electrical & Electronics	4.	• Power electronic circuits	CO4
	components available in the laboratory			
	using Digital Multimeters.			
LSO 4.2	Test the given power electronic			
	components using digital meters			
LSO 4.3	Identify the given Power Electronic Circuits			
	used in EVs			
LSO 4.4	Identify the components of the Charging		• Identification of Charging systems	
	System			
LSO 4.5	Recognize the types of Charging Systems			
	available in the Laboratory			

L) Sessional Work and Self-Learning: [2000511G]

a. Assignments: Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

b. Micro Projects:

1. Collect the information related to the performance of different types of electric vehicles and prepare a comparative report on economic and environmental analysis.
2. Collect specifications of different EVs available in the market.
3. Build and test a prototype circuit of converters used in an electric vehicle.
4. Visit a nearby Electric vehicle showroom or service centre & collect information on different types of motors used in electric vehicles and prepare a comparative report on their performance,
5. Visit a nearby charging station and prepare a report describing the layout and components of the charging station.

c. Other Activities:

1. Seminar Topics:
   - Communication Systems, Sensors and batteries used in Evs.
   - Technological advances in Evs
   - Comparison of EVs manufactured by different companies.
2. **Surveys** – Survey the market and gather information on the electric vehicle manufacturers and submit the report.
3. **Product Development**- Develop an electric vehicle prototype using locally procured hardware components.

d. Self-learning topics:

- Global Manufacturers of EV
- Indian Manufacturers of EV

- Motors used in EV
- Batteries used in EV
- Cost comparison of EVs in market

M) **Course Evaluation Matrix:** The course teacher has to decide and use the appropriate assessment strategy and its weightage, in theory, laboratory and sessional work for ensuring CO attainment. The response/performance of the student in each of these designed activities is to be used to calculate **CO attainment.**

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		**Sessional Work Assessment (SWA)**			**Lab Assessment (LA)#**	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	**End Theory Assessment (ETA)**	**Sessional Work & Self-Learning Assessment**			**Progressive Lab Assessment (PLA)**	**End Laboratory Assessment (ELA)**
			Assignments	**Micro Projects**	**Other Activities***		
CO-1	10%	10%	20%	--	33%	10%	20%
CO-2	15%	10%	20%	--	33%	15%	20%
CO-3	15%	30%	20%	--	34%	15%	20%
CO-4	30%	30%	20%	50%	--	30%	20%
CO-5	30%	20%	20%	50%	--	30%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

***:** Other Activities include seminars, visits, surveys, product development, software development etc.

******: Mentioned under point#: Mentioned under point

Note: For CO attainment calculation, Indirect assessment tools like Course exit survey need to be used which comprises of questions related to achievement of each COs.

N) **Specification Table for End Semester Theory Assessment:** The course teacher has to decide and use the appropriate assessment strategy and its weightage, in theory, laboratory and sessional work for ensuring CO attainment. The response/performance of the student in each of these designed activities is to be assessed to calculate CO attainment.

Unit Title and Number	Relevant COs Number(s)	Total Marks	ETA (Marks)		
			Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Introduction to Electric Vehicle	**CO1**	12	3	5	4
Unit-2.0 Electric Motors used in EVs.	**CO2**	15	4	6	5
Unit- 3.0 EV Batteries and Energy Storages.	**CO3**	20	5	9	5
Unit- 4.0 EV Charging Systems	**CO4**	15	5	6	4
Unit- 5.0 Regulatory Requirements and Policies for EV Industry	**CO5**	8	3	3	3
Total Marks		**70**	**20**	**29**	**21**

Note: Similar table can also be used to design class/mid-term/ internal question papers for progressive assessment.

O) Specification Table for Laboratory (Practical) Assessment:

S. N.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA (%)	PDA (%)	
1	Practice using digital meters such as AC, DC Clamp Meters, Digital Multimeters, Lux Meters, etc.	CO1	30	-	20
2	Practice using Screw Driver Kit, Vernier Caliper, Micrometer, Ampere Meter, Voltage Meter, and Techno-meter.				
3	Practice using safety kits.				
4	Identification of motors used in EV	CO2	15	40	30
5	Testing of Batteries used in EVs	CO3	15	40	30
6	Battery Management System	CO3			
7	Power electronic circuits	CO4	40	20	20
8	Identification of Charging systems	CO4			

Note: This table can be used for both the end semester as well as progressive assessment of practicals. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student's performance.

P) Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Field Trips, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Labs, and Field, Information and Communications Technology (ICT)Based, Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	AC, DC Clamp Meters	Application: Non-contact AC/DC Voltage and Current measurement **AC Application:** Current: 0-200Amp, Voltage: 0-600Volt **DC Application:** Current: 4-20mA, Voltage: 0-30Volt.	1
2.	Digital Multimeters	Display: 4 ½ digit Indications: overload protection, polarity indication, over range indication. Auto range change and auto polarity change facility, auto display of polarity and decimal point. **DC**: Volt: 200mV-600V, Current: 200mA-2A **AC**: Volt: 200mV-1000V, Current: 200mA-2A Resistance: 200W-20mW, Power supply: 230V, 50Hz Battery operation: 9 Volt battery Electronic components testing facility should be provided in the Multimeter. A provision for an A.C. adaptor(eliminator) must be available along with the multimeter.	1, 3
3.	Lux Meters	Functions: MAX / MIN, Backlight, Auto Power Off Range: 0 ~ 200,000 lux 0 ~ 20,000 fc Accuracy: ± 5% rdg + 10 dgt (< 10.000 lux / fc) ± 10% rdg +	1

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
		10 dgt (>10.000 lux / fc) Resolution: 0.1 lux or 0.1 fc Accessories: Carrying Case, Installation Manual, 9V Battery (installed).	
4.	Screw Driver toolbox	All types of screw drive sets.	1
5.	Vernier Caliper	**Range:** Lower scale: 0-200mm, Upper Scale: 0-12inch **Vernier Resolution:** Lower Scale: 0.02mm, Upper Scale: 0.001inch	1
6.	Micrometer	0-25mm (inside/outside)	1
7.	Ampere Meter	Moving iron and Moving Coil	1
8.	Voltmeter	AC(0-250V)/DC(0-24V)	1
9.	Tachometer	For speed measurement (0-3000rpm)	1
10.	Resistors	Low-value Resistors of different types	1,4
11.	Capacitors	Low-value electrolyte Capacitors.	1,4
12.	Inductors	Low-value inductors.	1,4
13.	Safety Kit	First Aid Kit, Helmet, Face Mask, Gloves etc.	1
14.	Motors for Electric Vehicle application	Brushless DC, Induction, Permanent Magnet Synchronous Motors, Switched Reluctance Motors	2
15.	EV Machine Cut-out section	for demonstration & training	2
16.	EV mock layout	for demonstration & training	2
17.	Lithium Ion Battery	12V, 7Ah	3
18.	Lead-acid battery	12V, 7Ah	3
19.	Nickel-based batteries (metal hydride and cadmium battery).	12V, 7Ah	3
20.	Battery internal resistance meter	For O.C. voltage & internal battery resistance of each cell	3
21.	Cell Capacity tester	Up to 15V batteries and 3A load current, 10mV voltage and 1mA current resolution, Automatic detection of termination voltage, LED display with a 3-button interface.	3
22.	BMS setup	For Demonstration & training	3
23.	DC power supply	0-32V	3
24.	Power diodes	Power diodes of different current values.	1, 4
25.	Transistors	Power Transistors (NPN, PNP) for Low-frequency high-power applications.	1,4
26.	Voltage Sensors	0-12 Volts.	1,3,4

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
27.	Current Sensors	Volts: + 15v, 0-5v, Current: 4-20mA.	1,3,4
28.	Converter Models	DC to DC and DA to AC converter model	4
29.	Charging Station Simulator	For Demonstration & training purposes.	4
30.	EV Technology layout 3D poster with frame	Fuel cell, EV- Charging Systems, HEV, FCEV, Motors & Controllers etc.	3,4

R) Suggested Learning Resources:

(a) Suggested Books :

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Handbook on Electric Vehicles Manufacturing (E-Car, Electric Bicycle, E- Scooter, E-Motorcycle, Electric Rickshaw, E- Bus, Electric Truck with Assembly Process, Machinery Equipments & Layout)	P.K. Tripathi	Niir Project Consultancy Services; 1st edition (1 January 2022) ISBN-13 : 978-8195676927
2.	Electric Vehicles: And the End of the ICE age	Anupam Singh	Kindle Edition ASIN : B07R3WFR28
3.	Wireless Power Transfer Technologies for Electric Vehicles (Key Technologies on New Energy Vehicles)	Xi Zhang, Chong Zhu, Haitao Song	Springer Verlag, Singapore; 1st ed. 2022 edition (23 January 2022) ISBN-13 : 978-9811683473
4.	Modern Electric, Hybrid Electric, and Fuel Cell Vehicles	EHSANI	CRC Press; Third edition (1 January 2019)ISBN-13 : 978-0367137465
5.	Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles	John G. Hayes, G. Abas Goodarzi	Wiley; 1st edition (26 January 2018) ISBN-13 : 978-1119063643
6.	New Perspectives on Electric Vehicles	Marian Găiceanu (Editor)	IntechOpen (30 March 2022) ISBN-13 : 978-1839696145

(b) Suggested Open Educational Resources (OER):

1. https://www.energy.gov/eere/fuelcells/fuel-cell-systems
2. https://powermin.gov.in/en/content/electric-vehicle
3. https://www.iea.org/reports/electric-vehicles
4. https://www.oercommons.org/search?f.search=Electric+Vehicles

Note: Teachers are requested to check the creative commons licence status/ financial implications of the suggested OER, before use by the students.

(c) Others: (If any)

1. Learning Packages
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

S) Course Curriculum Development Team(NITTTR)

- Dr. A. S. Walkey(Coordinator)
- Dr. S. S. Kedar(Co-coordinator)

A) Course Code : 2000505 H / 2000508 H / 2000511H

B) Course Title : Robotics (Basics)

C) Pre- requisite Course(s) :

D) Rationale :

Currently, industries demand non-stop and fine quality work in different processes used. It is difficult for the human beings to give same quantity and quality of work with respect to time, environment and complexity of the work in any process industry. To get quality and quantity of work in toughest environment or the environment which is not suitable for the humans to work, industries demand for robots and its operator. Operators who will operate these robots need some basic knowledge of robotics. To fulfill the need of industries and looking to the advancement in technology, this course aims for the diploma engineers to have knowledge and skills in robotics.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

Select robots for given applications employing basic concepts of design and functions of robots.

Interpret co-ordinate systems and degree of freedom for robots.

Use sensors and drives in context of various robotic applications.

Select appropriate robot control techniques,

Use programs to operate robots.

F) Course Articulation Matrix:

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes (PSOs) (if any)		
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**	**PSO-3**
CO-1	3	-	3	-	2	2	2			
	3	2	1	2	-	-	-			
CO-2	3	2	1	2	2	-	2			
CO-3	3	1	1	2	-	-	-			
CO-4	3	2	3	3	2	3	2			

Legend: High (3), Medium (2), Low (1) and No mapping (-)

G) Scheme of Studies:

Course Code	Course Title	Scheme of Studies (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (SW+ SL)	Total Hours (CI+LI+SW+SL)	Total Credits(C)
		L	T				
2000505H/ 2000508H/ 2000511H	Robotics (Basics)	02	-	04	02	08	05

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI : Laboratory Instruction (Includes experiments/practical performances in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

SW: Sessional Work/Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, open educational resources (OERs)

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: SW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Scheme of Assessment:

Course Code	Course Title	Scheme of Assessment (Marks)						Total Marks (TA+SWA+LA)
		Theory Assessment (TA)		Sessional Work Assessment (SWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Sessional Work Assessment (PSWA)	End Sessional Work Assessment (ESWA)	Progressive Lab Assessment(PLA)	End Laboratory Assessment (ELA)	
2000505H / 2000508H / 2000511H	Robotics (Basics)	30	70	**20**	**30**	20	30	200

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

SWA: Sessional Work/Term work & Self Learning Assessment (Includes assessment related to student performance in self learning, assignments, Seminars, micro projects, industrial visits, any other student activities etc.

Note: Separate passing is must for progressive and end semester assessment for both theory and practical.

I) Course Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: [2000505H]

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain the basic terms used in robotics TSO 1b. Identify components used in robots. TSO 1c. Explain various types of movements. TSO 1d. Distinguish various robots' configurations and their workspace. TSO 1e. Evaluate the degrees of freedom of the given robot. TSO 1f. Specify the methods of conversion of the given linear motion into rotary motion and vice-versa. TSO 1g. List the criteria for selecting robot for the given simple application with justification.	**Unit-1.0 Basics of Robotics Systems** 1.1 Definition, need, brief history of robotics 1.2 Basic Robot terminology,configuration and its working 1.3 Robot components overview - Manipulator, End effecters, Drive system, Controller, Sensors 1.4 Basic structure of a Robot and Classification – Cartesian, Cylindrical, Spherical, Horizontal articulated (SCARA),Parallel; Mechanic alarm, Degree of freedom, Links and joints, Wrist rotation,Mechanical transmission-pulleys, belts, gears, harmonic drive (gear box) 1.5 Linear and Rotary motion and its devices 1.6 Selection criteria for robots	CO1,CO2

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 2a. Explain the working of various types of End effecters used in robots with diagram. TSO 2b. Explain with sketches the function of the given sensing device used in a robot. TSO 2c. Describe working of the given sensor used in robot. TSO 2d. Explain the given robot configuration. TSO 2e. Select relevant robot sensors for a given application with justification. TSO 2f. Describe robot machine vision concepts along with block diagram of robot vision system. TSO 2g. Select vision equipment for a given robotic application.	**Unit– 2.0 Robot Components** 2.1 End effecters: types, sketches, working and applications 2.2 Sensing and Feedback devices: Optical sensors, Proximity sensors, LVDT, Thermocouple, RTD, Thermistor, Force sensing – strain gauge, Piezoelectric, Acoustic sensing Feedback devices; Potentiometers; Optical encoders; DC tachometers; 2.3 Robot machine vision: Block diagram of robot vision system, Vision equipment- camera, Imaging Components: Point, Line, Planar and Volume Sensors, Image processing, Part recognition and range detection	CO3
TSO 3a. Explain with sketches the function of the specified actuator used in a robot. TSO 3b. Differentiate between open loop and closed loop systems. TSO 3c. Explain various robotic controls. TSO 3d. Describe block diagrams of the given control system. TSO 3e. Specify drive system used for robotic control as per requirement. TSO 3f. Differentiate the various robot path controls. TSO 3g. Justify the selection of actuators, drives, control system, AC servo motor and path control for making of a robot.	**Unit– 3.0 Robotic Drive System and Controller** 3.1 Actuators; Hydraulic, Pneumatic and Electrical drives; linear actuator; Rotary drives 3.2 Control systems : Open loop and close loop with applications and its elements, Servo and non-servo control systems – Types, basic principles and block diagram Robot controller; Level of Controller 3.3 AC servo motor; DC servo motors and Stepper motors; 3.4 Robot path control: Point to point, Continuous path control and Sensor based path control	CO4
TSO 4a. Explain various robot programming languages. TSO 4b. Programme robot for a given simple job. TSO 4c. Describe the procedure to simulate the given robot movements using the relevant software.	**Unit– 4.0 Introduction to Robot Programming** 4.1 Need and functions of programming 4.2 Methods of robot programming: Manual Teaching, Teach Pendant, Lead through, Programming languages. Programming with graphics. 4.3 Programming languages: Types, features and applications 4.4 Controller programming 4.5 Simulation for robot movements	CO5
TSO 5a. Select a robot for the given application. TSO 5b. Describe various applications of Robotics. TSO 5c. Explain safety norms in robot handling. TSO 5d. Describe maintenance procedure for the given robot. TSO 5e. Describe common problems in robot operations and suggest remedial action.	**Unit– 5.0 Robotics Applications and Maintenance aspects** 5.1 Application robots including special types 5.2 Robot maintenance: Need and types 5.3 Common troubles and remedies in robot operation. 5.4 General safety norms, aspects and precautions in robot handling	CO1,CO2, CO3,CO4

Note: One major TSO may require more than one Theory session/Period.

K) Laboratory (Practical) Session Outcomes (LSOs) and List of Practical [2000508H]

Practical/Lab Session Outcomes(LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSOs 1.1 Identify parts of Robot on the basis of function. 1.2 Identify joint type & link parameters (link length, link twist, and Link offset), rotational vs. linear motion, used in robot.	1.	Identify components and different configurations of robots.	CO1
LSOs 2.1 Identify different types of robot end effecters. 2.2 Use Mechanical grippers to hold objects. 2.3 Use Vacuum grippers to hold objects.	2.	Pick/hold different objects (shape/weight/stiffness) using robot end effecters.	CO1, CO2
LSOs 3.1 Assemble the complete robot using the components as per the procedure 3.2 Apply the functionalities available in rotor trainer kit. 3.3 Test for various configurations. 3.4 Test for various degrees of freedom.	3.	Assemble robot to test various configurations and degrees of freedom using robot trainer kit.	CO1, CO2
LSOs 4.1 Identify various types of sensors used in robotic application. 4.2 Measure angular motion using Synchros. 4.3 Detect objects using optical sensors.	4.	Use different types of robotic sensors for a specific situation.	CO3
LSOs 5.1 Interface stepper motor. 5.2 Control robot with stepper motor interfacing.	5.	Perform robot control with stepper motor interfacing	CO3
LSOs 6.1 Draw the labelled sketch of individual parts and robot arm. 6.2 Assemble the arm using the parts as per the procedure. 6.3 Interface the motor drive and operate.	6.	Assemble robot arms using mechanical transmission components and interface motor drive.	CO2, CO3
LSOs 7.1 Use open source or available relevant software to develop pick and place programme. 7.2 Perform simulation.	7.	Perform pick and place operation using Simulation Control Software.	CO5
LSOs 8.1 Develop programme for using a robot arm with three degrees of freedom. 8.2 Execute the programme.	8.	Perform 2D simulation of a 3 DOF robot arm.	CO2, CO4, CO5
LSOs 9.1 Apply stepper motor control with direction control and step control logic simulation. 9.2 Perform basic PLC programming 9.3 Develop ladder logic programs 9.4 Use programming timers	9.	Programme 5-axis Robotic arm to control various motions.	CO3, CO4, CO5
LSOs 10.1Develop a program for a simple	10.	Program to execute a simple robot application	CO4, CO5

Practical/Lab Session Outcomes(LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
application. 10.2 Execute the robot programme.		(like painting, straight welding) using a given configuration.	

L) Sessional Work and Self Learning: [2000511H]

a. **Assignments**: Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

b. **Micro Projects:** A suggestive list of micro-projects is given here. Similar micro-projects that match the COs could be added by the concerned course teacher. The student should strive to identify eco-friendly or recycled material prior to selection for robotic applications.

1. Develop stair climb robot using robotic components.
2. Develop RF controller robot using robotic components.
3. Develop robot for metal detection application using robotic components.
4. Develop line follower robot using robotic components.
5. Develop solar floor cleaner robot using robotic components.
6. Develop solar tracker system using robotic components.
7. Develop a greenhouse managing robot for a horticulture application.

c. **Other Activities:**

1. Seminar Topics: Recent developments in the field of robotics
2. Visits: Visit an automation industry and prepare report for various types of robots employed there and details of any one type of special purpose robot used
3. Case Study: Identify a robotic application in automobiles and present a case study
4. Self learning topics:
    - History of industrial robot
    - Sociological consequences of Robots

M) Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and sessional work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate CO attainment.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Sessional Work Assessment (SWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Sessional Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	20%	20%	20%	10%	25%	10%	20%
CO-2	20 %	25%	20%	10%	25%	**20%**	20%
CO-3	25%	25%	20%	25%	25%	**20%**	20%
CO-4	20%	20%	20%	15%	25%	**20%**	20%
CO-5	15%	10%	20%	40%	--	30%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

***** : Other Activities include self learning, seminar, visits, surveys, product development, software development etc.

****** : Mentioned under point- (N)

\# : Mentioned under point-(O)

Note: For CO attainment calculation, Indirect assessment tools like Course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Specification Table for End Semester Theory Assessment: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and sessional work for ensuring CO attainment. The response/performance of the student in each of these designed activities is to be assessed to calculate CO attainment.

Unit Number and Title	Relevant COs Number(s)	Total Marks	ETA (Marks)		
			Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Basics of Robotics Systems	CO1,CO2	20	7	7	5
Unit– 2.0 Robot Components	CO2,CO3	16	3	8	5
Unit– 3.0 Robotic Drive System and Controller	CO3,CO4	12	4	4	5
Unit– 4.0 Introduction to Robot Programming	CO5	10	2	4	4
Unit– 5.0 Robotics Applications and Maintenance aspects	CO1,CO2, CO3,CO4	12	4	4	4
	Total Marks	**70**	**20**	**27**	**23**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Specification Table for Laboratory (Practical) Assessment:

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA (%)	PDA (%)	
1.	Identify components and different configurations of robots.	CO1	30	50	20
2.	Pick/hold different objects (shape/weight/stiffness) using robot end effecters.	CO1, CO2	60	30	10
3.	Assemble robot to test various configurations and degrees of freedom using robot trainer kit.	CO1, CO2	70	20	10
4.	Use different types of robotic sensors for a specific situation.	CO3	60	30	10
5.	Perform robot control with stepper motor interfacing	CO3	70	20	10
6.	Assemble robot arms using mechanical transmission components and interface motor drive.	CO2, CO3	60	30	10
7.	Perform pick and place operation using Simulation Control Software.	CO5	70	20	10
8.	Perform 2D simulation of a 3 DOF robot arm.	CO2, CO4, CO5	60	30	10
9.	Programme 5-axis Robotic arm to control various motions.	CO3, CO4, CO5	60	30	10
10.	Program to execute a simple robot application (like painting, straight welding) using a given configuration.	CO4, CO5	60	30	10

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Field Trips, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching

Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources(OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S.No.	**Name of Equipment, Tools and Software**	**Broad Specifications**	**Relevant Experiment/ Practical Number**
1.	Programmable Robot trainer kit	Trainer kit with - Minimum 3 linkages, Minimum 4 degree of freedom, Mechanical end effecter with servo control, interfacing card (RC servo output, sensors input)	1,2,3
2.	Robotic Arm Control Trainer Kit	botic Arm with five axis control application through PLC.; PLC; Digital Inputs: 8 Nos with 4mm banana sockets for getting the external inputs; Digital Outputs: 6 Nos with 4mm banana sockets for applying the inputs; Digital Input Controls: On board Toggle switches, Push Buttons & input potentiometers; Digital Outputs Controls: 6 nos. on board LED indicators; PC interfacing facility through RS-232.	8,9
3.	Proximity trainer kit	Indicator Type:LED; PCB Type Glass Epoxy SMOBC PCB; Interconnections**:** 2mm banana Patch cords; On board DC motor to see the application of Proximity sensor. Test points to analyse the signal On board variable supply to vary the speed of DC motor. ON/OFF switch and LED for power indication. All interconnections to be made using 2mm banana Patch cords. User manual and patch cords. Built-in power supply. Robust enclosure wooden/plastic box.	4
4.	Robot - Line Tracking Mouse Ki	Product Dimensions (20.3 x 11.4 x 8.9 cm); programmed IC, 2 unassembled gear motors, printed circuit boards, mouse-shaped plastic body, necessary components and wires, step-down power converter	3, 4,5
5.	Intelligent Robot Actuator Module	Integrity Serial Bus System, CAN to Build Intelligent Device Network, Open Hardware Platform, Arduino, to control Robot sub-Systems of motor-sensor, movable Omni Wheel of Omni-Directional, Actuator operation control by DC Encoder Motor, DC-Motor control and operation by Accelerometer, Gyro, Ultrasonic and PSD sensor, Androx Studio; brushless ILM 70×10 Robo Drive DC motor; sensor-actuator units of ARMAR-4; SD-25-160-2A-GR-BB Harmonic Drive reduction gear unit high gear ratio of 160: 1; structural parts (white) are made out of high-strength aluminium, Hollow shaft with strain gauges for torque sensing, motor's magnetic incremental encoder (AMS5306), digital buses (SPI or 12C); Motor interface PCB includes a 13-Bit temperature-to-digital converter with a temperature range from −40°C to 125°C (Analog Devices ADT7302)	3, 4, 5
6.	6-axis Robotics Trainer	Programmable robotic arm with an interactive front panel. Software to demonstrates functioning of the trainer as well as allows a user to develop their own	3, 4, 5

S.No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/ Practical Number
		programs. NV330; 8 bit microcontroller to ARM processors; Record and Play capability; Optional interfacing with PLC; Touch operated ON/OFF switch; Auto set to home position; Applications can be developed; Data acquisition using USB	
7.	Robotic Drive System	AC servo motor; DC servo motors, Stepper motors; DC tachometers, etc.	1,3,5,6,7,10
8.	Robot simulator for Robotics	Educational networking licensed Robotic system with simulation software	8, 10
9.	Assorted sensors	Optical encoders, Acoustic sensors ,IR, Potentiometer, RTD, Thermistor, strain gauge, piezoelectric, etc	4
10.	Vision equipment	Camera, Imaging Components: Point, Line, Planar and Volume Sensors	1, 4,10

R) Suggested Learning Resources:

(a) Suggested Books :

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Introduction to Robotics Mechanics and Control	John Craig	Pearson Education ; 978-9356062191
2.	Industrial Robotics -Technology, Programming and Applications	Nicholas Odrey Mitchell Weiss, Mikell Groover Roger Nagel, Ashish Dutta	McGraw Hill Education; 2nd Edition; 978 -1259006210
3.	Robotic engineering : an integrated approach	Richard D. Klafter, Thomas A. Thomas A. Chmielewski, Michael Negin	Prentice Hall of India, N.Delhi , 978-8120308428
4.	Industrial Robotics Technology, Programming and Applications	Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey	McGraw-Hill Education , Second Edition, 978-1259006210
5.	Robotics	Appuu Kuttan K. K.	Dreamtech Press, First Edition, 2020, 978-9389583281
6.	Introduction to Robotics: Analysis, Control, Applications	Saeed B.Niku	Wiley; Second Edition, 978-8126533121
7.	Essentials of Robotics Process Automation	S. Muhkerjee	Khanna Publication, First edition, 978-9386173751
8.	Robotics	R R Ghorpade , M M Bhoomkar	Nirali Prakashan 978-9388897020

(b) Suggested Open Educational Resources (OER):

1. https://archive.nptel.ac.in/courses/112/105/112105249/
2. https://openlearning.mit.edu/mit-faculty/residential-digital-innovations/task-centered-learning-intro-eecs-robotics
3. http://www.mtabindia.com/
4. http://www.robotics.org/
5. https://en.wikipedia.org/wiki/Industrial_robot
6. http://www.servodatabase.com

7. https://www.youtube.com/watch?v=fH4VwTgfyrQ
8. https://www.youtube.com/watch?v=aW_BM_S0z4k
9. https://uk.rs-online.com/web/generalDisplay.html?id=ideas-and-advice/robotic-parts-guide
10. https://www.automate.org/industry-insights/smarter-robot-grasping-with-sensors-software-the-cloud
11. https://www.iqsdirectory.com/articles/machine-vision-system.html

Note: Teachers are requested to check the creative commons licence status/ financial implications of the suggested OER, before use by the students.

(c) Others: (If any)

1. Learning Packages
   - https://www.edx.org/learn/robotics
   - https://www.coursera.org/courses?query=robotics
   - https://www.udemy.com/topic/robotics/
   - https://library.e.abb.com/public/9a0dacfdec8aa03dc12578ca003bfd2a/Learn%20with%20ABB.%20Robotic%20package%20for%20education.pdf

2. Users' Guide
   - https://roboindia.com/store/DIY-do-it-your-self-educational-kits-robotics-embedded-system-electronics
   - https://www.robomart.com/diy-robotic-kits
   - https://www.scientechworld.com/robotics

3. Lab Manuals
   - http://www-cvr.ai.uiuc.edu/Teaching/ece470/docs/ROS_LabManual.pdf
   - https://www.jnec.org/labmanuals/mech/be/sem1/Final%20Year%20B.Tech-ROBOTICS%20LAB%20%20MANUAL.pdf

MICROCONTROLLER APPLICATIONS ABORATORY
(ELECTRICAL ENGINEERING GROUP)

<table>
<tr><td rowspan="4">Subject Code
2020506</td><td colspan="3">Practical</td><td colspan="3">No of Period in one session:</td><td>Credits</td></tr>
<tr><td colspan="3">No. of Periods Per Week</td><td>Full Marks</td><td>:</td><td>50</td><td rowspan="3">02</td></tr>
<tr><td>L</td><td>T</td><td>P/S</td><td>Internal (PA)</td><td>:</td><td>15</td></tr>
<tr><td>—</td><td>—</td><td>04</td><td>External (ESE)</td><td>:</td><td>35</td></tr>
</table>

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Maintain microcontroller-based systems.
- To introduce students with the architecture and operation of typical microprocessors and micro controllers.
- To familiarize the students with the programming and interfacing of microprocessors and micro controllers.
- To provide strong foundation for designing real world applications using microprocessors and microcontrollers.

CONTENTS: PRACTICAL

1. Demonstration and study of microprocessor kit [02]
2. Program for addition of and subtraction of two hexa decimal numbers [02]
3. Interpret details of Hardware kit for Microcontroller and practice to write and execute pro-grams. [02]
4. Identify different menus available in a simulator software RIDE/KEIL and demonstrate their use. [02]
5. Develop and execute Assembly language programs using Arithmetic Instructions and demonstrate outcome for a given input data [02]
6. Develop and execute Assembly language programs using Logical Instructions and demonstrate Outcome for a giveninput [02]
7. Develop and execute an Assembly language program for Addition of series of 8 bit nos, 16 bit
8. result and demonstrate outcome for a given input data [02]
9. Develop and execute Assembly language program for addition/subtraction of 16 bit no/multibyte nos. and demonstrate outcome for a given inputdata [03]
10. Develop and execute Assembly language program for Block transfer from and to Internal/External memory using directives and demonstrate outcome for a given inputdata. [03]
11. Develop and execute Assembly language program Largest/smallest of given series of no. from Internal/External memory and demonstrate outcome for a given inputdata. [03]
12. Develop and execute Assembly language program arrange no in ascending/descending order from Internal/External memory and demonstrate outcome for a given inputdata. [03]
13. Develop and execute Assembly language program for LED blinking/LED sequences using delay/timer mode. [03]
14. Develop and execute Assembly language program to interface LED with microcontroller. [02]

30

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

CO 1 : Interpret the salient features of various types of microcontrollers.
CO 2 : Interpret the salient features of architype of types microcontrollers IC8051
CO 3 : Maintain the program features of the Microcontroller based application
CO 4 : Develop assembly language program
CO 5 : Develop program to interface 8051 microcontrollers with LED/SWITCH

ENERGY CONSERVATION AND AUDIT
ELECTRICAL ENGINEERING GROUP)

<table>
<tr><td rowspan="4">Subject Code
2020507</td><td colspan="3">Practical</td><td colspan="3">No of Period in one session:</td><td>Credits</td></tr>
<tr><td colspan="3">No. of Periods Per Week</td><td>Full Marks</td><td>:</td><td>25</td><td rowspan="3">01</td></tr>
<tr><td>L</td><td>T</td><td>P/S</td><td>Internal (PA)</td><td>:</td><td>07</td></tr>
<tr><td>—</td><td>—</td><td>02</td><td>External (ESE)</td><td>:</td><td>18</td></tr>
</table>

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Undertake energy conservation and energy audit.

CONTENTS: PRACTICAL

1. Identify star labelled electrical apparatus and compare the data for various starratings. [02]
2. Determine the '% loading' of the given loaded Induction motor. [02]
3. Determine the reduction in power consumption in star mode operation of Induction motor compared to delta mode. [02]
4. Use APFC unit for improvement of p. f. of electrical load. [02]
5. Compare power consumption of different types of TL with choke, electronic ballast and LED lamps by direct measurements. [02]
6. Determine the reduction in power consumption by replacement of lamps in a class room /laboratory. [02]
7. Determine the reduction in power consumption by replacement of Fans and regulators in a classroom /laboratory. [02]
8. Collect electricity bill of an industrial consumer and suggest suitable tariff for energy conservation and its impact on energy bill. [02]
9. Collect electricity bill of a commercial consumer and suggest suitable tariff for conservation and reduction of its energy bill. [02]
10. Collect electricity bill of a residential consumer and suggest suitable means for conservation and reduction of the energy bill. [02]
11. Estimate energy saving by improving power factor and load factor for given cases. [02]
12. Prepare a sample energy audit questionnaire for the given industrial facility. [02]
13. Prepare an energy audit report(Phase-I) [02]
14. Prepare an energy audit report(Phase-II) [02]
15. Prepare an energy audit report(Phase-III) [02]

30

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

CO 1 : Interpret energy conservation policies inIndia.
CO 2 : Implement energy conservation techniques in electrical machines.

CO 3 : Apply energy conservation techniques in electrical installations.
CO 4 : Use Co-generation and relevant tariff for reducing losses in facilities.

ELECTIVE LAB / COE LAB
ELECTRICAL TESTING AND COMMISIONING LABORATORY
(ELECTRICAL ENGINEERING GROUP)

<table>
<tr><td rowspan="4">Subject Code
2020508A</td><td colspan="3">Practical</td><td colspan="3">No of Period in one session:</td><td>Credits</td></tr>
<tr><td colspan="3">No. of Periods Per Week</td><td>Full Marks</td><td>:</td><td>50</td><td rowspan="3">02</td></tr>
<tr><td>L</td><td>T</td><td>P/S</td><td>Internal (PA)</td><td>:</td><td>20</td></tr>
<tr><td>—</td><td>—</td><td>04</td><td>External (ESE)</td><td>:</td><td>30</td></tr>
</table>

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Follow standard safety procedures in testing and commissioning of electrical equipment.

CONTENTS: PRACTICAL

1. Determine break down strength of transformer oil. [04]
2. Perform insulation resistance test on any one motor/transformer. [06]
3. Prepare trouble shooting charts for electrical machines such as Transformer, D.C. machines, Induction motor, and Synchronous machines [06]
4. Measure impedance voltage and load losses of three-phase transformer. [06]
5. Find regulation and efficiency of single-phase transformer by direct loading and back-to-back connection method and compare theresults. [06]
6. Determine efficiency of D.C. machine by Swinburne'stest. [06]
7. Determine efficiency of D.C. machine by Hopkinson'stest. [06]
8. Perform reduced voltage running up test on three-phase Induction motor as per I.S.325-1967. [06]
9. Measure no load losses and no load current of a transformer as perIS. [06]
10. Perform no load test on single phase Induction motor for the measurements of no load current, power input, and speed at rated voltage as perI.S. [08]
11. Perform temperature rise test on single-phase transformer. [08]
12. Find efficiency of M.G.set [08]

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

CO 1 : Follow safety procedures with respect to earthing and insulation of electrical equipment

CO 2 : Select proper tools, equipment, for installation, testing, maintenance of electrical machines and transformers

CO 3 : Test and commission electrical equipment in accordance with IScodes

CO 4 : Make plans for troubleshooting electrical machines

CO 5 : Undertake regular preventive and break down maintenance.

ELECTIVE LAB / COE LAB
ELECTRICAL ESTIMATION AND COSTING
(ELECTRICAL ENGINEERING GROUP)

<table>
<tr><td rowspan="4">Subject Code
2020508B</td><td colspan="3">Practical</td><td colspan="3">No of Period in one session:</td><td>Credits</td></tr>
<tr><td colspan="3">No. of Periods Per Week</td><td>Full Marks</td><td>:</td><td>50</td><td rowspan="3">02</td></tr>
<tr><td>L</td><td>T</td><td>P/S</td><td>Internal (PA)</td><td>:</td><td>20</td></tr>
<tr><td>—</td><td>—</td><td>04</td><td>External (ESE)</td><td>:</td><td>30</td></tr>
</table>

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Design electrical installation with costing for tendering.

CONTENTS: PRACTICAL

1. Prepare a tender notice for purchasing a transformer of 200 KVA for commercial installation.
2. Prepare a quotation for purchasing different electrical material required.
3. Prepare a comparative statement for above material Prepare purchase order for thesame.
4. Design drawing, estimating and costing of hall / cinema theater / commercial installation Pre- pare report and draw on sheet.
5. Design electrical installation scheme for any one factory / small industrial unit. Draw detailed wiring diagram. Prepare material schedule and detailed estimate. Prepare report and draw on sheet.
6. Estimate with a proposal of the electrical Installation of street light scheme for small premises after designing.
7. Estimate with a proposal of the L.T. line installation. Prepare report and draw on sheet.
8. Estimate with a proposal of the 500 KVA, 11/0.433 KV outdoor substation and prepare a report

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

CO 1 : Follow National Electrical Code 2011 in electrical installations.

CO 2 : Estimate the electrical installationworks

CO 3 : Estimate the work of non-industrial electrical installations.

CO 4 : Estimate the work of industrial electrical installations.

CO 5 : Prepare abstract, tender, quotation of public lighting and other installations.

CO 6 : Prepare abstract, tender, quotation of low tension (LT)substations.

ELECTIVE LAB / COE LAB
SWITCHGEAR AND PROTECTION LABORATORY
(ELECTRICAL ENGINEERING GROUP)

Subject Code 2020508C	Practical			No of Period in one session:			Credits
	No. of Periods Per Week			Full Marks	:	50	02
	L	T	P/S	Internal (PA)	:	20	
	—	—	04	External (ESE)	:	30	

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Maintain switchgear and protection schemes used in electrical power systems.

CONTENTS: PRACTICAL

1. Identify various switchgears in the laboratory and write their specifications.
2. Test HRC fuse by performing the loadtest.
3. Test MCB by performing the loadtest
4. Dismantle MCCB/ELCB and identify variousparts.
5. Dismantle ACB/VCB and identify different parts.
6. Set the plug and time (with PSM, TSM) of induction type electro magnetic relay.
7. Test electromagnetic over-current relay by performing load test.
8. Simulate differential protection scheme for transformer with power system simulation kit.
9. Test the working of the single phasing preventer using a three-phase induction motor.
10. Simulate transmission line protection by using the impedance relay/over current relay for various faults. (On transmission line protection simulation Kit).
11. Dismantle Thyrite type arrester and identify different parts.
12. Perform neutral earthing at different substations /locations.

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

CO 1 : Identify various types of faults in power system.

CO 2 : Select suitable switchgears for different applications.

CO 3 : Test the performance of different protective relays.

CO 4 : Maintain protection systems of alternators and transformers.

ELECTIVE-IV LABORATORY
ILLUMINATION PRACTICES LABORATORY
(ELECTRICAL ENGINEERING GROUP)

<table>
<tr><td rowspan="4">Subject Code
2020509A</td><td colspan="3">Practical</td><td colspan="3">No of Period in one session:30</td><td>Credits</td></tr>
<tr><td colspan="3">No. of Periods Per Week</td><td>Full Marks</td><td>:</td><td>25</td><td rowspan="3">01</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>Internal (PA)</td><td>:</td><td>07</td></tr>
<tr><td>—</td><td>—</td><td>02</td><td>External (ESE)</td><td>:</td><td>18</td></tr>
</table>

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Design illumination schemes and associated electrification of buildings.

CONTENTS: PRACTICAL

1. Conduct illumination level assessment in workplace using luxmeter.
2. Fit the given lamp in the selected mounting
3. Interpret the polar curves of the given type of lamp and verify it using the luxmeter
4. Measure the illumination output of different lamps (Incandescent, Fluorescent, CFL, LED, HPSV, HPMV) and compare it with theirwattage.
6. Measure illumination level with and without reflectors used in the various Luminaries.
7. Estimate and compare luminous efficiency of incandescent and compact fluorescentlamp.
8. Prepare light dimmer arrangement using the relevant dimmer type oftransformer
9. Identify the given types of dimmer transformer and theirparts
10. Build an electronic dimmer – Part I
11. Build another type of electronic dimmer – Part II
12. Build a single lamp control by single switch
13. Build a single lamp control by two switches
14. Build a single lamp control circuit for two point method
15. Build a lamp control circuit for three-point method
16. Build a lamp control circuit for four-point method.

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry-oriented COs associated with the above-mentioned competency:

CO 1 : Select the relevant Illumination levels for various applications

CO 2 : Select relevant lamps for various applications

CO 3 : Select the lighting accessories required for selected wiring scheme.

CO 4 : Design relevant illumination schemes for interior applications.

CO 5 : Design Illumination schemes for various applications

CO 6 : Design Illumination schemes for various outdoor applications.

ELECTIVE IV

INDUSTRIAL AUTOMATION AND CONTROL LABORATORY (ELECTRICAL ENGINEERING GROUP)

Subject Code 2020509B	Practical			No of Period in one session:30			Credits
	No. of Periods Per Week			Full Marks	:	25	01
	L	T	P	Internal (PA)	:	07	
	—	—	02	External (ESE)	:	18	

Course objectives:

The aim of this course is to help the student to attaint he following industry identified competency through various teaching learning experiences:

- Maintain Industrial AutomationSystems

Practical's:

1. Identify various automation systems available in different appliances/ devices/ machines in day-to-dayuse.
2. Identify various parts of the given PLC and front panel status indicators.
3. Use PLC to test the START STOP logic using two input sand one output.
4. Develop/Executea ladder program for the given application using following:-timer,counter, comparison, logical, arithmetic instructions.
5. Use PLC to control the following devices like lamp, motor, push button switches, proximity sensor
6. Measure the temperature of the given liquid using RTD or Thermo couple and PLC.
7. Develop/test ladder program to blink the LED/lamp.
8. Develop/test the Ladder program for sequential control application of lamps/DC motors.
9. Develop ladder program for Traffic light control system.
10. Develop and test ladder program for pulse counting using limit switch/Proximity sensor.
11. Develop/test ladder program for Automated car parking system.
12. Develop/test ladder program for Automated elevator control.
13. Develop/test ladder program for rotating step per motor in forward and reverse direction at constant speed.
14. Develop/test ladder program for tank water level control.
15. Develop/test ladder program for control of speed of step per motor with suitable drivers.
16. Identify various front panel controls of VFD (smartdrive).
17. Control speed of AC/DC motor using VFD.(VFD-Variable Frequency Drive)
18. Use various functions of SCADA simulationed it ors to develop simple project.
19. Develop a SCAD Amimic diagram for Tank level control.
20. Develop SCAD Amimic diagram for Flow control in a given system.
21. Simulate Tank level control using available SCADA system.

Course outcomes:

The theory , practical experience sand relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry-oriented Cos associated with the above-mentioned competency:

CO 1 : Identify different types of automation systems.

CO 2 : Interface I/O devices with the PLC modules.

CO 3 : Develop PLC ladder programs for various applications.

CO 4 : Select the suitable motor drives for different applications.

CO 5 : Prepare simple SCADA applications

****

ELECTIVE-IV
ELECTRIC TRACTION
(ELECTRICAL ENGINEERING GROUP)

Subject Code 2020509C	Practical			No of Period in one session:30			Credits
	No. of Periods Per Week			Full Marks	:	25	01
	L	T	P/S	Internal (PA)	:	07	
	-	-	02	External (ESE)	:	18	

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Maintain electric tractionsystems

CONTENTS: PRACTICAL

1. Dismantle a traction motor
2. Assemble a traction motor
3. Troubleshoot a traction motor
4. Visit electric-traction train lighting system installation, identify components of system and prepare report
5. Visit electric-traction loco shed, investigate working of each section & prepare report
6. Visit to Traction Substation or feeding post (for layout and OHE) and write a report
7. Visit to Railway Station (for signalling and train lighting) and writing a report on visit
8. Draw traction substation Layout on drawing sheet and prepare report
9. Draw Pentagonal OHE Catenary, different Catenaries according to speed limit, OHE support- ing structure on drawing sheet and prepare report
10. Draw Power Circuit of AC Locomotive on drawing sheet and prepare report.

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

CO 1 : Interpret the traction layout and its systems

CO 2 : Maintain the power supply arrangements.

CO 3 : Maintain the function of the overhead equipment for electric traction

CO 4 : Maintain the different components of the electric locomotive.

CO 5 : Maintain the traction motor and train lighting system

CO 6 : Maintain the signal in gand supervisory control systems.

TERM WORK

MINOR PROJECT.

Subject Code 2020510	Term Work			No of Period in one session:			Credits
	No. of Periods Per Week			Full Marks	:	50	02
	L	T	P/S	Internal (PA)	:	15	
	—	-	04	External (ESE)	:	35	

Course objectives:

The projects if done right can help enthusiastic electrical engineering students to develop the skills/profile needed for an exciting career in core technologies. Since practical skills are very important to work on core industries, experts tend to analyse candidate's performance based on their project experience during theinterviews.

These projects provide an excellent opportunity to learn and showcase your practical skills to your future interviewers easily. If spent qualitatively you can build a very innovative electrical project and get a great learning experience. By doing so, you will not only develop an innovative project but also develop valuable skills needed for a successful career in core technologies related to electrical engineering. The best way to master a subject is by doing projects. Through a project you not only get a deeper understanding of the subject but also gain hands-on practical experience. If you are looking to do internships in college, the best way to catch the companies attention is throughprojects.

Projects are generally done as a combined team effort. Two or more students work under a guide or a staff to get a certain results. By doing a project, you will

- Understand your subject better
- Get practical experience
- Chance to showcase your skills
- Learn about team work, communication skills and responsibilities

When companies look for interns, they prefer students who have good understanding of the subject with atleast some hands on experience. The best to achieve both is by doing projects.

There is no fixed time to do a project. You can do it right from your first year in college. If you are looking to do a technical project, then the best time to start would be mid second year. It's not mandatory that you do many projects but make sure that you atleast do one project. A lot of students tend to do few small projects from their second year and do a big project in their final year. By showcasing your projects, you can even look for internships while in college.

You can do any kind of projects based on your interests or subjects. The best way to go about this is to figure out what you are interested in. So the first step is to find your interest and then do projects in your area of interest.

Find your area of interest and then do a project in that field.

You can start by exploring different areas and then pick the field in which you are interested in. You can learn more about it and start working on small problems.

Few examples:

1.Home Automation using IOT

2.Battery Management System using Arduino

3. Smart Energy Meter using GSM

4. Implementation of a Web of Things Based Smart Grid to Remotely Monitor and Control Renewable Energy Sources

5. Home Automation System

6. Enerbee - Example of an Advanced Metering Infrastructure based on Zigbee

7. Solar & Smart Energy Systems

8. Power Factor Metering System using Arduino

9. Automatic Solar Tracker
10. Using Arduino Development Platform in the Diagnosis of AC Electrical Machines
11. ArduinoProjects
12. Design and Implementation of Real Time Transformer Health Monitoring System using Gsm Technology
13. Smart Energy Projects
14. DesignandImplementationofanAdvanced Security System - Invisible Eye (Power Saving System)
15. PCB Manufacturing
16. Foot StepbasedPower GenerationandMulti-Purpose Optimization
17. MATLAB for Engineers
18. Universal Electrical Power Generationand Multipurpose Optimization – Solar, Wind and Rain
19. Digital Signal Processing using MATLAB
20. Electrical SubstationScrutinizingand Controlling Device from Remote Area
21. Simscape Electrical using MATLAB
22. Wireless Power Transmission
23. Image Processing using MATLAB
24. Transformer IndustrialParametersManagement Control System and Intimation to Electricity Board
25. Advanced Image Processing using MATLAB
26. Online Speed Control of DC Motor with High Speed Network
27. Digital Signal Processing using Python
28. Energy Scrutiny System with Auto Load
29. Circuit DesignwithProteus
30. Talking Energy Meter
31. PCB Design and Simulation with KiCAD
32. MicroControllerbasedIntelligent Multi Timer System for Industrial Automation
33. Lab VIEW for Engineers
34. Auto Digital-Speed Indicator with Speed Control
35. PLC Programming for Engineers
36. GSM and PIR Sensor based Light Controller and Networked Safety System
37. Smart Traffic Lighting System
38. Electric Field and Ultrasonic Sensor based Security System
39. Automation using PLC
40. Mobile Controlled DC Motor Speed Controller

Similar many on related to branch.

TERM WORK

Course under Moocs / NPTEL / Others

<table>
<tr><td rowspan="4">Subject Code

2020511</td><td colspan="3">Term Work</td><td colspan="3">No of Period in one session:30</td><td>Credits</td></tr>
<tr><td colspan="3">No. of Periods Per Week</td><td>Full Marks</td><td>:</td><td>50</td><td rowspan="3">01</td></tr>
<tr><td>L</td><td>T</td><td>P/S</td><td>Internal (PA)</td><td>:</td><td>20</td></tr>
<tr><td>-</td><td>-</td><td>02</td><td>External (ESE)</td><td>:</td><td>30</td></tr>
</table>

Course objectives:

ABOUT SWAYAM:

This is done through a platform that facilitates hosting of all the courses, taught in classrooms from Class 9 till post-graduation to be accessed by anyone, anywhere at any time. All the courses are interactive, prepared by the best teachers in the country and are available, free of cost to any learner.
More than 1,000 specially chosen faculty and teachers from across the country have participated in preparing these courses.

The courses hosted on SWAYAM are in 4 quadrants – (1) video lecture, (2) specially prepared reading material that can be downloaded/printed (3) self-assessment tests through tests and quizzes and (4) an online discussion forum for clearing the doubts. Steps have been taken to enrich the learning experience by using audio-video and multi-media and state of the art pedagogy / technology.

In order to ensure that best quality content is produced and delivered, nine National Coordinators have been appointed. They are:

AICTE (All India Council for Technical Education) for self-paced and international courses NPTEL (National Programme on Technology Enhanced Learning) for Engineering
UGC (University Grants Commission) for non-technical post-graduation education CEC (Consortium for Educational Communication) for under-graduate education NCERT (National Council of Educational Research and Training) for school education NIOS (National Institute of Open Schooling) for school education
IGNOU (Indira Gandhi National Open University) for out-of-school students IIMB (Indian Institute of Management, Bangalore) for management studies
NITTTR (National Institute of Technical Teachers Training and Research) for Teacher Training programme

Courses delivered through SWAYAM are available free of cost to the learners, however learners wanting a SWAYAM certificate should register for the final proctored exams that come at a fee and attend in- person at designated centres on specified dates. Eligibility for the certificate will be announced on the course page and learners will get certificates only if this criteria is matched. Universities/colleges approving credit transfer for these courses can use the marks/certificate obtained in these courses for the same.

Below is a list of all SWAYAM courses categorized by subject. **Student can register to portal and complete the course.**

Humanities
Business
Programming
Mathematics
Social Sciences
Data Science
Education & Teaching
Computer Science
Health & Medicine
Personal Development
Science
Engineering
Art & Design

STATE BOARD OF TECHNICAL EDUCATION,BIHAR

Scheme of Teaching and Examinations for

VIth SEMESTER DIPLOMA IN ELECTRICAL ENGINEERING/ ELECTRICAL & ELECTRONIC ENGINEERING.

(Effective from Session 2020-21 Batch)

THEORY

Sr. No.	SUBJECT	SUBJECT CODE	TEACHING SCHEME	EXAMINATION-SCHEME							
			Periods per Week	Hours of Exam.	Teacher's Assessment (TA) Marks A	Class Test (CT) Marks B	End Semester Exam. (ESE) Marks C	Total Marks (A+B+C)	Pass Marks ESE	Pass Marks in the Subject	Credits
1.	Entrepreneurship and start –ups	2000601	3	3	**10**	**20**	**70**	100	28	**40**	3
2.	Building Electrification	2020602	4	3	**10**	**20**	**70**	100	28	**40**	4
3.	Utilization of Electrical Energy	2020603	4	3	**10**	**20**	**70**	100	28	**40**	4
4.	Open Elective -I	2020604	3	3	**10**	**20**	**70**	100	28	**40**	3
	Network Theory(2020604A)				Disaster Management(2015604B)						
5.	Open Elective -II / COE		3	3	**10**	**20**	**70**	**100**	**20**	**20**	2
	Indian Constitution (2000605A)			Project Management (2015605B)				Artificial Intelligence **(Advance)** (2000605B)			
	Internet of Things **(Advance)** (2000605C)		Drone Technology **(Advance)** (2000605D)				3D Printing & Design **(Advance)** (2000605E)				
	Industrial Automation **(Advance)** (2000605F)		Electric Vehicles **(Advance)** (2000605G)				Robotics **(Advance)** (2000605H)				
	Total: -		17				**350**	500			16

PRACTICAL

Sr. No.	SUBJECT	SUBJECT CODE	TEACHING SCHEME	EXAMINATION-SCHEME					
			Periods per Week	Hours of Exam.	Practical: Internal (PA)	Practical: External (ESE)	Total Marks	Pass Marks in the Subject	Credits
6.	Elective Lab / COE Lab		4	3	20	30	50	20	2
	Building Electrification Laboratory (2020608A)			Artificial Intelligence **(Advance)** Lab (2000608B)			Internet of Things **(Advance)** Lab (2000608C)		
	Drone Technology **(Advance)** Lab (2000608D)			3D Printing & Design **(Advance)** Lab (2000608E)			Industrial Automation **(Advance)** Lab (2000608F)		
	Electric Vehicles **(Advance)** Lab (2000608G)			Robotics **(Advance)** Lab (2000608H)					
	Total: -		04				50		02

TERM WORK

Sr. No.	SUBJECT	SUBJECT CODE	TEACHING SCHEME	EXAMINATION-SCHEME				
			Periods per Week	Marks of Internal (PA)	Marks of External (ESE)	Total Marks	Pass Marks in the Subject	Credits
7.	Seminar	2020609	4	15	35	50	20	2
8.	Major Project	2020610	6	30	70	100	40	3
9.	Term Work		2	20	30	50	20	1
	Course Under Moocs /NPTEL/ Others TW (2020611)	Artificial Intelligence (Advance) TW (2000611B)		Internet of Things (Advance) TW (2000611C)		Drone Technology (Advance) TW (2000611D)		
	3D Printing & Design (Advance) TW (2000611E)	Industrial Automation (Advance) TW (2000611F)		Electric Vehicles (Advance) TW (2000611G)		Robotics (Advance) TW (2000611H)		
	Total: -		12			200		06
Total Periods per week Each of duration One Hour 33					Total Marks = **750**			24

ENTREPRENEURSHIP AND START –UPS

Subject Code 2000601	Theory			No of Period in one session: 42			Credits
	No. of Periods Per Week			Full Marks	:	100	03
	L	T	P/S	ESE	:	70	
	03	—	—	TA	:	10	
				CT	:	20	

Course Objectives:

The main aims of the course are to familiarize students with various concepts used in understanding processes involved in entrepreneurship and business formation and development.

- To acquire Entrepreneurial spirit and resourcefulness.
- To familiarize with various uses of human resource for earning dignified means of living.
- To understand the concept and process of entrepreneurship - its contribution and role in the growth and development of individual and the nation.
- To acquire entrepreneurial quality, competency, and motivation.
- To learn the process and skills of creation and management of entrepreneurial venture.

CONTENTS: THEORY

Unit	Name of Topics	Hrs.
Unit-I	Introduction to Entrepreneurship and Start – Ups • Definitions, Traits of an entrepreneur, Entrepreneurship, Motivation • Types of Business Structures, Similarities and differences between entrepreneurs and managers.	**06**
Unit-II	Business Ideas and their implementation • Discovering ideas and visualizing the business • Activity map • Business Plan	**06**
Unit-III	Idea to Start-up • Market Analysis – Identifying the target market, • Competition evaluation and Strategy Development, • Marketing and accounting, • Risk analysis	**10**
Unit-IV	Management • Company's Organization Structure, • Recruitment and management of talent. • Financial organization and management	**08**
Unit-V	Financing and Protection of Ideas • Financing methods available for start-ups in India • Communication of Ideas to potential investors – Investor Pitch • Patenting and Licenses	**08**
Unit-VI	Exit strategies for entrepreneurs, bankruptcy, and succession and harvesting strategy.	**04**
	Total	**42 hrs.**

References:

1. The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company, Steve Blank and Bob Dorf, K & S Ranch ISBN – 978- 0984999392
2. The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses, Eric Ries, Penguin UK ISBN – 978-0670921607
3. Demand: Creating What People Love Before They Know They Want It Adrian J. Slywotsky with Karl Weber, Headline Book Publishing ISBN – 978- 0755388974
4. The Innovator's Dilemma: The Revolutionary Book That Will Change the Way You Do Business, Clayton M. Christensen, Harvard business ISBN: 978-142219602
5. Entrepreneurship and Start-ups, Ekta Sharma, FPH

SUGGESTED SOFTWARE/LEARNING WEBSITES:

a. https://www.fundable.com/learn/resources/guides/startup
b. https://corporatefinanceinstitute.com/resources/knowledge/finance/corporatestructure/
c. https://www.finder.com/small-business-finance-tips
d. https://www.profitbooks.net/funding-options-to-raise-startup-capital-for-your-business/

Course outcomes:

Upon completion of the course, the student will be able to :

CO : 1 Understand the dynamic role of entrepreneurship and small businesses

CO :2 Organize and Manage a Small Business

CO : 3 Plan the Financial strategy and Control

CO : 4 Operate forms of Ownership for Small Business

CO : 5 Make Strategic Marketing Planning

CO : 6 Launch new Product or Service Development

CO : 7 Conceive business Plan

*****

BUILDING ELECTRIFICATION

(ELECTRICAL ENGINEERING GROUP)

Subject Code 2000602	Theory			No of Period in one session : 56			Credits
	No. of Periods Per Week			Full Marks	:	100	04
	L	T	P/S	ESE	:	70	
	04	—	—	TA	:	10	
	—	—	—	CT	:	20	

Course Objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Recognize the different conductor systems used in residential and light commercial wiring in accordance with the codes and authorities for installation.
- Design electrical installation systems in building complexes.

CONTENTS: THEORY

Unit	Name of Topics	Hrs.
Unit-I	Wiring Tools and Accessories Various tools required for wiring- screwdrivers, pliers, Try square, saws, hacksaw, chisel, hammers, mallet, punch, hand drill machine, portable drilling machine, files, plumb bob, line thread, electricians' knife, test lamp, tester and their BIS specifications, application, care & maintenance of tools. Classification of electrical accessories- controlling, holding, safety, outlet BIS symbols of following electrical accessories. Switch – Their types according to construction such as surface switch, flush switch, and pull switch, rotary switch, knife switch, pendent switch, Main-switch (ICDP, ICTP). Their types according to working such as single pole, double pole, two-way, two-way center off, intermediate, series parallel switch Holders- Their types such as bayonet cap lamp holder, pendent holder, batten lamp holder, angle holder, bracket holder, tube light holder, screw type Edison and goliath Edison lamp holder, swivel lamp holder. Socket outlets and plugs- two pin, three-pin, multi pin sockets, two-pin and three- pin plug. Others- Iron connector, adaptor, and ceiling rose, distribution box, neutral link, bus-bar chamber. Wooden/ mica boards, Moulded / MS Concealed boxes of different sizes. Modular accessories.	**12**
Unit-II	Electrical Wires and Underground Cables Conductors: - wire, cable, bus bar, stranded conductor, cable, armoured cable, flexible cable, solid conductor, PVC wires, CTS wire, LC wire, FR (Fire retardant) wire, Size of wire according to BIS. Tools used for measurement of wire size, Wire jointing methods. Classification of cables, low tension, high tension, and extra high-tension cables, solid, oil filled and gas filled type Cable insulation materials –vulcanized rubber (VIR), polyvinyl chloride (PVC), cross linked polythene (XLPE), impregnated paper, Selection of suitable cable size and type from standard data Cable jointing methods Cable laying methods. Factors determining selection of electric cables	**14**
Unit-III	Wiring Methods and wiring layout Factors determining the selection of wiring methods. Classification of wiring methods. PVC casing-capping wiring- wiring rules according to IS: 732-1983 Conduit wiring- Types of conduits, comparison between Metal and PVC conduit, types of conduit wiring (Surface/Concealed). Conduit wiring accessories, BIS rules for Metal and PVC conduit wiring.	**06**

	Comparison of various wiring systems. General BIS rules for domestic installations. Design, working and drawing of following electrical circuits: Simple light and fan circuits, Stair case wiring, Go-down wiring circuit, Bedroom lighting circuit, Corridor lighting circuit, Series parallel circuit, Master switch control circuit, Different lighting circuit using - Intermediate switch, Call bell circuit using bell indicator, Design of wiring circuits according to user's requirement	
Unit-IV	Residential Building Electrification Domestic Dwellings/Residential Buildings: reading of Civil Engineering building drawing, Interpretation of electrical installation plan and electrical diagrams, electrical symbols as per IS: 732. Electrical installation for residential building as per part I section 9 of NEC-2011 Difference between residential and industrial load, rules/requirements related to lighting load followed in electrical installations, Positioning of equipment. Lighting and power circuits: Light and fan circuit, Power circuit Wiring and circuit Schematic diagram according to IS: 2042(Part-I)-1962: multiline and single line representation Load assessment: Selection of size of conductor, Selection of rating of main switch and protective switch gear. Design and drawing, estimation and costing of a residential installation having maximum 5 KW load; Sequence to be followed for preparing estimate; Calculation of length of wire and other materials, labour cost Testing of wiring installation as per IS: 732-1982: Insulation resistance - between earth and conductors, between conductors, polarity test of single pole switches. Testing of earth continuity path. Residential building Service Connection- types Underground and overhead. Calculation of Material required for service connection	**10**
Unit-V	Protection of Electrical Installation Fuse in electric circuit: fuse element, fuse current rating, minimum fusing current, cut-off current, fusing factor, Fuse material Types of fuses –Re-wirable, cartridge fuses (HRC and LRC), Fuse material Selection of fuse. Miniature circuit Breaker (MCB)-Construction, Principle rating and uses, Earth Leakage ker (ELCB)-Construction, Principle rating and uses. System and equipment earthing and its requirements, Earth, earth electrode, earth current, earth terminal, earthing wire, earthing lead, fault current, leakage current, Measurement of earth resistance using earth tester, Methods of reducing earth resistance, Methods of earthing as per IS 3043: 1987 and their procedure- Driven pipe, pipe and plate earthing, modern methods of earthing,	**08**
Unit-VI	Illumination in Residential Installation Concept of Luminous flux, Luminous intensity, Lumen, Illumination or illuminance, Lux, Space-height ratio, utilization factor, depreciation factor, luminous efficiency- values for different luminaries. Laws of Illumination-Inverse Square Law, Cosine Law, illumination received directly underneath, horizontal screen and screen moved horizontally at certain distance Factors affecting the illumination. Different types of lighting arrangements, Luminous flux of different types of light sources, Lux level required for different places asper SP 72:2010.	**06**
	Total	**56**

References:

1. Raina, K.B. and S.K.Bhattacharya, Electrical Design Estimating and Costing, New Age Interna- tional Ltd., New Delhi, ISBN978-81-224-0363-3
2. Allagappan,N. S.Ekambarram, Electrical Estimating and Costing, New Delhi, ISBN-13: 9780074624784
3. Singh, Surjit, Electrical Estimating and Costing, Dhanpat Rai and Co. New Delhi, ISBN: 1234567150995
4. Gupta, J B: A Course in Electrical Installation Estimating and Costing, S K Kataria and Sons,New Delhi,ISBN:978-93-5014-279-0
5. Bureau of Indian Standard, IS: 732-1989, Code of practice for electrical wiringinstallation
6. Bureau of Indian Standard, SP 30 National Electrical Code2010
7. Bureau of Indian Standard, SP 72 National Lighting Codes2010

E-REFERENCES: -

- http://nptel.ac.in/courses/108108076/1 , assessed on 18th January2016
- http://www.electrical4u.com, assessed on 18th January2016
- https://www.youtube.com/watch?v=A9KSGAnjo2U, assessed on 18th January2016
- http://www.electricaltechnology.org/2015/09, assesed on 30 Jan2016
- www.slideshare.net/bawaparam/made-by-paramassesed on 30Jan2016
- www.electricaltechnology.org/2013/09/electrical-wiring.html assessed on 16 March2016.

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

CO 1 : Select accessories, wires, cables and wiring systems for electrification.

CO 2 : Design electrical wiring installation system for residential unit.

CO 3 : Design proper illumination scheme for residential unit.

CO 4 : Prepare wiring layouts on wiring board.

CO 5 : Locate and diagnose faults in electrical wiring installation.

CO 6 : Do proper earthing for building electrification.

****

UTILIZATION OF ELECTRICAL ENERGY

(ELECTRICALENGINEERINGGROUP)

Subject Code 2020603	Theory						Credits
	No. of Periods Per Week			Full Marks	:	100	04
	L	T	P/S	ESE	:	70	
	04	—	—	TA	:	10	
	—	—	—	CT	:	20	

CONTENTS: THEORY

	Name of the Topic	Hours	Marks
Unit-01	Illumination: 1.1 Definitions of Terms Used in Illumination: Light, Luminous Flux, Luminous Intensity, Lumen, Candle Power, Illumination, Lux or Meter Candle, Mean Horizontal Candle Power (MHCP), Mean Spherical Candle Power (MSCP), Mean Hemi-spherical Candle Power (MHSCP), Reduction Factor, Lamp Efficiency, Specific Consumption, Glare, Space-Height Ratio, Utilization Factor, Maintenance Factor, Depreciation Factor, Waste Light Factor, Absorption Factor, Reflection Factor, Solid Angle. 1.2 Laws of Illumination:Law of Inverse SquaresLambert's Cosine Law. (No Numerical) 1.3 Sources of Light: Construction, Working and Applications of Following LamIncandescent Lamps. Halogen Lamps. Low Pressure Mercury Vapour Lamps (Fluorescent Tube).High Pressure Mercury Vapour Lamps.\Sodium Vapour Lamps. Compact Fluorescent Lamps (C.F.L.)MetalHalide Lamps LED LampsNeon Signs. 1.4 – Basic Principles of Light Control. 1.5 – Types of Lighting Schemes. Direct, Semi-direct, Semi-indirect, Indirect, General Lighting. 1.6 – Design of Lighting Scheme: Objectives of Lighting Scheme. Factors to be considered While Designing the LightingScheme. (SimpleNumericals) 1.7 - Factory Lighting: - General Requirements - Types of Installations: General Lighting, Local Lighting, Emergency Lighting. 1.8 Lumen or Light Flux Method of Lighting Calculations. (SimpleNumericals) 1.9 – Flood Lighting - Flood Lighting Purposes. - Classification of Projectors. - Location and Mounting of Projectors. (Simple Numericals)	14	14

Unit-02	Electric Heating and Welding: Electric Heating: 2.1.1 – Advantages of Electric Heating. 2.1.2 – Modes of Transfer of Heat: - Conduction, Convection and Radiation. 2.1.3 – Classification of Electric Heating Methods: 2.1.4 – Resistance Heating:(Construction & Operation) - Direct Resistance Heating: Salt Bath Furnace. - Indirect Resistance Heating: Resistance Ovens, Requirements of Heating Element Material, Causes of Failure of Heating Elements, Methods of Temperature Control. - Applications of Resistance Heating. 2.1.5 – Arc Heating: (Construction & Operation) - Direct Arc Furnace: - Indirect Arc Furnace. - Applications of Arc Heating. 2.1.6 – Induction Heating: (Construction & Operation) - Core Type Induction Furnaces: Ajax Wyatt Furnace. - Coreless Induction Furnace. - Applications of Induction Heating. (Simple Numericals on Melting Furnaces) 2.1.7 – Dielectric Heating: - Principle of Dielectric Heating. - Advantages of Dielectric Heating - Limitations of Dielectric Heating. - Applications of Dielectric Heating. (Simple Numericals on Dielectric Heating) Electric Welding: 2.1 – Methods of Electric Welding: Electric Arc Welding, Resistance Welding. 2.2.2 – Resistance Welding: - Principle of Resistance Welding. - Advantages of Resistance Welding. - Types of Resistance Welding-(Only List) 2.2.3 – Spot Welding Machine. 2.2.4 – Electric Arc Welding: - Formation and Characteristics of Electric Arc. - Effect of Arc Length. - Arc Blow. 2.2.5 – Polarity in DC Welding: 2.2.6 – Electrodes for Metal Arc Welding: 2.2.7 – V-I Characteristics of Arc Welding DC Machines.	16	10 10
Unit-03	Elevators: 3.1 Types of electric elevators 3.2 Size and shape of elevator car 3.3 Speed of elevators 3.4 Location of elevator machine 3.5 Types of elevator machines, elevator motors 3.6 Power transmission gears braking 3.7 Safety in elevators 3.8 Bombay lift act.	08	08

Unit-04	Electric Drives: 4.1 – Introduction: - What is drive? - Drives – Mechanical Drive and Electric Drive. 4.2 – Advantages and Disadvantages of Electric Drive. 4.3 – Factors Governing Selection of Electric Motors. 4.4 - Nature of Electric Supply: 3 ϕ & 1ϕ AC and DC. 4.5 - Type of Drive: Group Drive & Individual Drive. 4.6 - Nature of Load: Nature of the Mechanical Load, Matching of the Speed Torque Characteristics of the Motor with that of the Load, and Starting Conditions of the Load. 4.7 - Electrical Characteristics: (Only DC Series, Three Phase and Single Phase Induction Motors are to be dealt) - Running Characteristics: Three Typical Speed Torque Characteristics – Inverse, Constant Speed and Drooping. - Starting Characteristics: Starting Torque only. (No Starters). - Speed Control: Suitability to Economic and Efficient Speed Control Methods (Above and Below Normal Speed). - Braking Characteristics: Plugging, Rheostatic Braking and Regenerative Braking, as Applied to DC Series and Three Phase Induction Motor. 4.8 - Mechanical Features: - Type of Enclosure as per IS - Type of Bearings - Type of Transmission for Drive - Noise Level. 4.9 - Size of Motor: - Load Conditions – Continuous Loads, Short Time Loads, Intermittent Loads, Continuous Operation with Short Time Loads and Continuous Operation with Intermittent Loads. - Duty Cycles. - Standard Ratings for Motors as per ISS. - Estimation of Rating of a Motor. (Simple Numericals on Estimating Size of Continuously Rated Motor) - Load Equalisation. (No Calculations) 4.10 - Cost:	16	18
Unit-05	Economic Aspects of Utilising Electrical Energy: 6.1 – Economic Aspects of Utilising Electrical Energy. 6.2 – Costing of Electrical Energy: Fixed Charges, Semi Fixed Charges and Running Charges. 6.3 – Formulation of Electrical Tariffs. 6.4 – Various Types of Tariffs: Tariffs in force for Domestic, Commercial and Industrial Consumers. 6.5 – Power Factor Improvement: Causes of Low Power Factor, Disadvantages of Low Power Factor, Power Factor Improvement by using Static Capacitors, Location of Capacitors for Power Factor Improvement, Most Economical Power Factor. Automatic Power Factor Controller (Derivation and Simple Numerical) 6.6 – Energy Conservation: Importance and need of Energy Conservation, Measures for Energy Conservation in (i) Electric Drives (ii) Electric Traction (iii) Electric Heating (iv) Refrigeration and Air Conditioning (v) Illumination.	10	10
	Total	64	70

Text / Reference Books:		
Titles of the Book	Name of Authors	Name of the Publisher
Art & Science of Utilisation of Electrical Energy	H. Partab	Dhanpat Rai & Sons
Utilisation of Electric Power & Electric Traction.	J. B. Gupta	S. K. Kataria & Sons
Utilisation of Electric Power & Electric Traction.	G. C. Garg	Khanna Publishers
Electric Traction	J. Upadhyay S. N. Mahendra	Allied Publisher Ltd.
Fundamentals of Electrical Drives	G. K. Dubey	Narosa Publishing House.
Generation & utilization of Electrical Energy	S. Shivnagaraju, M. Balasubba Reddy, D. Srilatha	Pearson Publications
Utilization of Electrical Energy	E. Openshaw Taylor	Orient Longman Pvt. Ltd.
Utilization of Electrical Energy	Rajiv Ranjan	Foundation Publishing

NETWORK THEORY
(ELECTRICAL ENGINEERING GROUP)

Subject Code	Theory						Credits
2020604A	No. of Periods Per Week			Full Marks	:	100	03
	L	T	P/S	ESE	:	70	
	03	—	—	TA	:	10	
	—	—	—	CT	:	20	

CONTENTS: THEORY

——	Name of the Topic	Hours
Unit-01	BASIC CIRCUIT ELEMENTS & WAVEFORMS:	[07]
	01.01 Circuit Components	
	01.02 Standard Input Signals	
	01.03 Sinusoidal Signals	
Unit-02	MESH AND NODE ANALYSIS:	[09]
	02.01 Kirchoff's Laws.	
	02.02 Source Transformation.	
	02.03 Mesh & Node analysis.	
	02.04 Magnetic coupling.	
Unit-03	FOURIER SIERIES:	[06]
	03.01 All forms of Fourier Series including trigonometry, Exponential etc.	
	03.02 Fourier Transform.	
Unit-04	LAPLACE TRANSFORM & THEIR APPLICATION:	[07]
	04.01 Introduction.	
	04.02 Laplace Transformation.	
	04.03 Application of Laplace Transform in the solution of Linear DifferentialEquation.	
	04.04 Inverse Laplace Transform.	
Unit-05	RESONANCE:	[03]
	05.01 Series Resonance.	
	05.02 Parallel Resonance	
Unit-06	TWO-PORT NETWORK:	[12]
	06.01 Introduction.	
	06.02 Open Circuit Impedance Parameters.	
	06.03 Short Circuit Admittance.	
	06.04 Two Port Symmetry.	
Unit-07	PASSIVE NETWORK SYNTHESIS:	[10]
	07.01 Introduction.	
	07.02 Positive real function.	
	07.03 Two Terminal R-L Network.	
	07.04 Two Terminal R-C Network.	
Unit-08	INTRODUCTION OF FIRST ORDER & SECOND ORDER SYSTEMS WITH EXAMPLES:	[06]
	Total	**60**

Books Recommended: -

1.	Network & system	-	D. Roy Choudhury
2.	Network & system	-	G.K. Mittal
3.	Network & system	-	Vulkenberg
4.	Network & system	-	Dacsur & Kuo
5.	Network Theory	-	R.N. Pathak

Disaster Management

Subject Code 2015604B	Theory			No of Period in one session: 42			Credits
	No. of Periods Per Week			Full Marks	:	100	03
	L	T	P/S	ESE	:	70	
	03	—	—	TA	:	10	
				CT	:	20	

Course Objectives:

Following are the objectives of this course:

- To learn about various types of natural and man-made disasters.
- To know pre and post disaster management for some of the disasters.
- To know about various information and organizations in disaster management in India.
- To get exposed to technological tools and their role in disaster management.

CONTENTS: THEORY

Unit	Name of Topics	Hrs
Unit-I	**Understanding Disaster:** • Understanding the Concepts and definitions of Disaster, Hazard, Vulnerability, Risk, Capacity– Disaster and Development, and disaster management.	06
Unit-II	**Types, Trends, Causes, Consequences and Control of Disasters:** • Geological Disasters (earthquakes, landslides, tsunami); Hydro- Meteorological Disasters (floods, cyclones, lightning, thunder-storms, hail storms, avalanches, droughts, cold and heat waves) Biological Disasters (epidemics, pest attacks, forest fire); • Technological Disasters (chemical, industrial, radiological, nuclear) and Manmade Disasters (building collapse, rural and urban fire, road and rail accidents, nuclear, radiological, chemicals and biological disasters) Global Disaster Trends – Emerging Risks of Disasters– Climate Change and Urban Disasters.	10
Unit-III	**Disaster Management Cycle and Framework:** • Disaster Management Cycle – Paradigm Shift in Disaster Management. Pre-Disaster – Risk Assessment and Analysis, Risk Mapping, zonation and awareness. • During Disaster – Evacuation – Disaster Communication – Search and Rescue – Emergency Operation Centre – Incident Command System – Relief and Rehabilitation • Post-disaster – Damage and Needs Assessment, Restoration of Critical Infrastructure– Early Recovery – Reconstruction and Redevelopment.	10
Unit-IV	**Disaster Management in India:** • Disaster Profile of India – Mega Disasters of India and Lessons Learnt. Disaster Management Act 2005. • National Policy on Disaster Management, National Guidelines and Plans on Disaster Management. • Role of Government (local, state and national), Non-Government and Inter Governmental Agencies	10
Unit-V	**Applications of Science and Technology for Disaster Management:** • Geo-informatics in Disaster Management (GIS, GPS and RS). Disaster Communication System (Early Warning and Its Dissemination). • S&T Institutions for Disaster Management in India.	06
	Total	**42 hrs.**

References:

1. Publications of National Disaster Management Authority (NDMA) on Various Templates and Guidelines for Disaster Management
2. Bhandani, R.K., An overview on natural & manmade disasters and their reduction, CSIR, NewDelhi
3. Srivastava, H.N.,and Gupta G.D., Management of Natural Disasters in developing countries, Daya Publishers, Delhi
4. Alexander ,David ,Natural Disasters ,Kluwer Academic London
5. Ghosh ,G.K., Disaster Management ,APH Publishing Corporation
6. Murthy,D.B.N.,Disaster Management :Text & Case Studies , Deep & Deep Pvt. Ltd.

Course outcomes:

After completing this course, student will be able to:

CO : 1 Acquaint with basic information on various types of disasters

CO : 2 Know the precautions and awareness regarding various disasters

CO : 3 Decide first action to be taken under various disasters

CO : 4 Familiarize with organization in India which are dealing with disasters

CO : 5 Select IT tools to help in disaster management

******

INDIAN CONSTITUTION

Subject Code 2000605A	Theory						Credits
	No. of Periods Per Week			Full Marks	:	100	02
	L	T	P/S	ESE	:	70	
	03	—	—	TA	:	10	
	—	—	—	CT	:	20	

Course Learning Objectives: At the end of each unit of learning students will be able to...

- To Enable the student to understand the importance of constitution
- To understand the structure of executive, legislature and judiciary
-
- To understand philosophy of fundamental rights and duties
- To understand the autonomous nature of constitutional bodies like Supreme Court and high court, controller and auditor general of India and election commission of India.
- To understand the central and state relation, financial and administrative

CONTENTS: THEORY

Unit	Name of Topics	Hrs.
Unit-I	The Constitution - Introduction • The History of the Making of the Indian Constitution • Preamble and the Basic Structure, and its interpretation • Fundamental Rights and Duties and their interpretation • State Policy Principles	**08**
Unit-II	Union Government • Structure of the Indian Union • President – Role and Power • Prime Minister and Council of Ministers • Lok Sabha and Rajya Sabha	**10**
Unit-III	State Government • Governor – Role and Power • Chief Minister and Council of Ministers • State Secretariat	**08**
Unit-IV	Local Administration • District Administration • Municipal Corporation • Zila Panchayat	**08**
Unit-V	Election Commission • Role and Functioning • Chief Election Commissioner • State Election Commission	**08**
	Total	**42 hrs**

References:

1. Ethics and Politics of the Indian Constitution Rajeev Bhargava Oxford University Press, New Delhi,2008
2. The Constitution of India B.L. Fadia Sahitya Bhawan; New edition(2017)
3. Introduction to the Constitution of India DD Basu Lexis Nexis; Twenty-Third 2018edition

Suggested Software/Learning Websites:

a. https://www.constitution.org/cons/india/const.html
b. http://www.legislative.gov.in/constitution-of-india
c. https://www.sci.gov.in/constitution
d. https://www.toppr.com/guides/civics/the-indian-constitution/the-constitution-of-india/

*****

PROJECT MANAGEMENT

Subject Code 2015605B	Theory			No of Period in one session : 42			Credits
	No. of Periods Per Week			Full Marks	:	100	02
	L	T	P/S	ESE	:	70	
	03	—	—	TA	:	10	
				CT	:	20	

Course Objectives:

Following are the objectives of this course:

- To develop an understanding of key project management skills and strategies.
- To make them understand the concepts of Project Management for planning and execution of projects.
- To make them understand the feasibility analysis in Project Management and network analysis tools for cost and time estimation.
- To enable them to comprehend the fundamentals of Contract Administration, Costing and Budgeting.
- To make them capable to analyze, apply and appreciate contemporary project management tools and methodologies in Indian context.

CONTENTS: THEORY

Unit	Name of Topics	Hrs.
Unit-I	**Concept of a project:** • Classification of projects- importance of project management- The project life cycle, establishing project priorities (scope- cost- time) project priority matrix- work break down structure.	**05**
Unit-II	**Capital budgeting process:** • Planning, Analysis, Selection, Financing Implementation- Review. Generation and screening of project ideas-market and demand analysis, Demand forecasting techniques. Market planning and marketing research process- Technical analysis	**10**
Unit-III	**Financial estimates and projections:** • Cost of projects-means of financing- estimates of sales and production, cost of production-working capital requirement and its financing- profitability projected cash flow statement and balance sheet. Break even analysis.	**07**
Unit-IV	**Basic techniques in capital budgeting:** • Non discounting and discounting methods- pay- back period- Accounting rate of return-net present value- Benefit cost ratio- internal rate of return. Project risk. Social cost-benefit analysis and economic rate of return. Non-financial justification of projects.	**08**
Unit-V	**Project administration:** • Progress payments, expenditure planning, project scheduling and network planning, use of Critical Path Method (CPM), schedule of payments and physical progress, time-cost trade off. • Concepts and uses of PERT cost as a function of time, Project Evaluation and Review Techniques, cost mechanisms. Determination of least cost duration. Post project evaluation.	**12**
	Total	**42 hrs.**

References:

1. Project planning, analysis, selection, implementation and review – Prasanna Chandra – Tata McGraw Hill
2. Project Management – the Managerial Process – Clifford F. Gray & Erik W. Larson - McGraw Hill
3. Project management - David I Cleland - McGraw Hill International Edition, 1999
4. Project Management – Gopala Krishnan – McMillan India Ltd.
5. Project Management-Harry-Maylor-Pearson Publication

Course outcomes:

At the end of the course, the student will be able to:

CO 1 : Understand the importance of projects and its phases.

CO 2 : Analyze projects from marketing, operational and financial perspectives.

CO 3 : Evaluate projects based on discount and non-discount methods.

CO 4 : Develop network diagrams for planning and execution of a given project.

*****

A) **Course Code** : **2000605B/2000608B/2000611B**

B) **Course Title** : Artificial Intelligence (Advance)

C) **Pre- requisite Course(s)** : Artificial Intelligence (Basic)

D) **Rationale** :

In Artificial Intelligence (Basic) course, students have learned the basics for Artificial Intelligence problem solving techniques, data analytics and articulates the different dimensions of these areas. This Artificial Intelligence (Advance) course offers the students the comprehension of Machine learning which is a subset of artificial intelligence in the field of computer. The course also exposes students to Tens or flow a Python-based open source library for numerical computation used in machine learning and developing neural networks. After completing the course students will be able to implement various techniques used in machine learning and neural networks using open source tools.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensurethe accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/laboratory/workshop/field/ industry.

After completion of the course, the students will be able to-

CO-1 Elaborate the use of Machine learning in Artificial Intelligence.

CO-2 Implement various supervised and unsupervised learning models and methods.

CO-3 Illustrate Artificial neural networks and its applications.

CO-4 Implement various Neural network models and Learning Methods.

CO-5 Solve machine learning and artificial neural network problems using Tens or flow.

F) **Suggested Course Articulation Matrix (CAM):**

Course Outcomes (COs)	**Programme Outcomes(POs)**							**Programme Specific Outcomes* (PSOs)**	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	-	2	2	-	-	-	1		
CO-2	3	3	3	3	-	-	2		
CO-3	-	3	3	3	-	-	2		
CO-4	3	1	3	3	-	-	2		
CO-5	3	3	3	3	-	-	2		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

***:** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Board of Study	Course Code	Course Title	Scheme of Study (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credit (C)
			L	T				
	2000605B/2000608B/2000611B	Artificial intelligence (Advance)	03	-	04	02	09	05

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances/ problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCS, spoken tutorials, online educational resources etc.

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Assessment Scheme:

Board of Study	Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
	2000605B/2000608B/2000611B	Artificial Intelligence (Advance)	30	70	20	30	20	30	200

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- Separate passing is must for progressive and end semester assessment for both theory and practical.
- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

I) Course Curriculum Detailing: This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number (s)
TSO 1a. Describe the basic terminology of Machine learning TSO 1b. Explain the concept of dataset and ways to handle them TSO 1c. illustrate the process of dataset division TSO 1d. Explain process involved in machine learning	**Unit – 1: Introduction to machine learning** Concept of Machine Learning, Define Learning, Learn the Network, Evaluate the Network, datasets and ways to handle them, Feature sets, Dataset division: test, train and validation sets, cross validation. Applications of Machine Learning, processes involved in Machine Learning	**CO-1**
TSO 2a. Identify the category or class of a particular dataset using KNN algorithm TSO 2b. Use Linear regression for predictive analysis TSO 2c. Predict the categorical dependent variable using Logistic Regression TSO 2d. Use SVM for classification problems in Machine Learning TSO 2e. determine the performance of the classification models TSO 2f. evaluate the performance of the classification model using ROC-curve TSO 2g Explain characteristics of Unsupervised learning. TSO 2h. Explain different clustering methods TSO 2i. Implement K-means clustering algorithm to group the unlabeled dataset	**Unit 2: Supervised and unsupervised learning** **Supervised learning:** Introduction to Supervised Learning, K-Nearest Neighbor, Linear Regression, Logistic Regression, Support Vector Machine (SVM), Evaluation Measures: confusion matrix, precision, precision and recall, ROC-Curve (Receiver Operating Characteristic curve) **Unsupervised learning:** Introduction to Unsupervised Learning, Introduction to clustering, Types of Clustering: Hierarchical, Agglomerative Clustering and Divisive clustering; Partitional Clustering - K-means clustering. Expectation-Maximization (EM) Algorithm	**CO-2**
TSO 3a. Explain Structure and working of Biological Neural Network. TSO 3b. differentiate between Artificial Neural Network and Biological Neural Network TSO 3c. State key historical points in development of ANN TSO 3d. Explain the architecture of an artificial neural network	**Unit 3: Introduction to neural networks** Structure and working of Biological Neural Network, Fundamentals of Artificial Neural Networks & Applications, Characteristics of Artificial Neural Networks, History of neural network research, characteristics of neural networks terminology.	**CO-3**
TSO 4a. Use neuron McCulloch – Pitts model in designing logical operations TSO 4b. Apply Rosenblatt's Perceptron to solve linear classification problems	**Unit 4: Neural networks models and Learning Methods** Models of neuron McCulloch – Pitts model,	**CO-4**

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number (s)
TSO 4c. Implement Adaptive Linear Neuron (Adaline) training algorithm in neural network TSO 4d. Use Backpropagation neural training algorithm TSO 4e. Use ART (Adaptive Resonance Theory) learning model TSO 4f: Implement Bidirectional Associative Memory (BAM) model in Artificial Neural Network	Rosenblatt's Perceptron, Adaline model, Basic learning laws, Topology of neural network architecture, Multilayer Neural Networks, Learning Methods, Backpropagation, Counter propagation, Adaptive Resonance Theory (ART), Associative memories, BAM.	
TSO 5a. Illustrate the features of Tens or flow TSO 5b. Manipulate tensors TSO 5c. Explain features of Tens or Board visualization TSO 5d Explain the concept and features of Tens or flow playground	**Unit-5 Tensor flow** features of TensorFlow, Tensor Data structure- Rank, shape, type, one dimension and two-dimension tensor, Tensor handling and manipulations, Tensor board visualization- symbols Tensors, Variables, Automatic differentiation, Graphs and tf.function, modules layers and models, training loops, features of Tens or flow playground- data ,the ration of train and test data, features, hidden layers, Epoch, learning rate, activation function, regularization, problem type	**CO-5**

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: (2000608B)

Practical/Lab SessionOutcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Implement data classification algorithms	1	Write a program to implement k-Nearest Neighbour algorithm to classify the iris data set. Print both correct and wrong predictions. Python ML library classes can be used for this problem.	**CO-2**
LSO 2.1 Implement Machine learning algorithms LSO 2.2 Evaluate the performance of classification model	2	(a) Implement SVM for Iris Dataset- download the dataset from (https://gist.github.com/netj/8836201) (b) Find confusion matrix and evaluation matrix for SVM Hint: SVM model can be constructed using sklearn command, import pandas as pd from sklearn.svm import SVC from sklearn.model_selection import train_test_split from sklearn.metrics import confusion_matrix from sklearn.metrics import classification_report from sklearn.metrics import accuracy_score 1. Read the csv Iris dataset file 2. Condition the data 3. Condition the training and Testing data 4. Construct the Linear model 5. Test the model with Linear kernel 6. Prepare confusion matrix 7. prepare Classification Report	**CO-2**

Practical/Lab SessionOutcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 3.1 Perform clustering operations using k-means algorithm	3	a) Explore k-means algorithm for the small sample dataset. b) Explore k-means algorithm for Iris Dataset	**CO-2**
LSO 4.1 Perform clustering operations using EM algorithm	4	Apply EM algorithm to cluster a set of data stored in a .CSV file. Use the same data set for clustering using k-Means algorithm. Compare the results of these two algorithms and comment on the quality of clustering. You can add Python ML library classes/API in the program.	**CO-2**
LSO 5.1 Build artificial neural network LSO 5.2 Test artificial neural network	5	Build an Artificial Neural Network by implementing the Backpropagation algorithm and test the same using appropriate data sets.	**CO-4**
LSO 6.1 Detect features or business intelligence in the input data using perceptron	6	Implement the perceptron algorithm from scratch in python.	**CO-4**
LSO 7.1 Use Tensors for given problems	7	Write a programme to implement two dimension and three-dimension Tensor.	**CO5**
LSO 8.1 Use basic features for tensor handling and manipulations	8	Write a programme to add and multiply two 4x4 matrix, you can Import "tens or flow" and "numpy".	**CO5**
LSO 9.1 Test artificial intelligence (AI) algorithms through the use of Google's TensorFlow machine learning libraries.	9	Solve a classification problem on the Tens or flow playground. Hint: refer https://www.educba.com/tensorflow-playground/	**CO5**
LSO 10.1 Implement artificial intelligence (AI) algorithms through the use of Google's TensorFlow machine learning libraries LSO 10.2 perform predictive analysis using linear regression	10	Implement algorithm for linear regression in tens or flow	**CO5, CO2**

L) **Suggested Term Work and Self Learning (2000611B):** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. Assignments: Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

b. Micro Projects:

Use python programming for the solutions of Microproject problems

1. (a) Create a Bar plot to get the frequency of the three species of the Iris data.
   (b) Create a Pie plot to get the frequency of the three species of the Iris data.
   (c) Write a Python program to create a graph to find relationship between the sepal length and width.

2. (a) Write a Python program to split the iris dataset into its attributes (X) and labels (y). The X variable contains the first four columns (i.e. attributes) and y contains the labels of the dataset.
   (b) Write a Python program using Scikit-learn to split the iris dataset into 70% train data and 30% test data. Out of total 150 records, the training set will contain 120 records and the test set contains 30 of those records. Print both datasets.

3. Conduct performance analysis of Classification Algorithms (any 2) on a specific dataset.

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of the student in each of these designed activities is to be assessed to calculate CO attainment.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment(ETA)	Term Work & Self-Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	20%	15%	30%	20%	30%	--	--
CO-2	10%	25%	20%	20%	20%	30%	33%
CO-3	30%	25%	30%	20%	20%	--	--
CO-4	20%	20%	20%	20%	30%	30%	33%
CO-5	20%	15%	10%	20%	--	40%	34%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

*	:	Other Activities include self-learning, seminar, visits, surveys, product development, software development etc.
**	:	Mentioned under point- (N)
#	:	Mentioned under point- (O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0. Introduction to machine learning	7	**CO1**	11	5	4	2
Unit-2.0. Supervised and unsupervised learning	10	**CO2**	18	5	6	7
Unit-3.0. Introduction to neural networks	10	**CO3**	17	5	7	5
Unit-4.0.Neural networks models and Learning Methods	8	**CO4**	14	3	3	8
Unit-5.0. Tensor flow	10	**CO5**	10	2	6	2
Total Marks	**45**		**70**	**20**	**26**	**24**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

SN	Laboratory Practical Titles		Relevant COs Number(s)	PLA/ELA		
				Performance		Viva-Voce (%)
				PRA*(%)	PDA**(%)	
1.	Write a program to implement k-Nearest Neighbor algorithm toclassify the iris data set. Print both correct and wrong predictions. Python ML library classes can be used for this problem.		CO-2	-	80	20
2.	(a) Implement SVM for Iris Dataset- download the dataset from(https://gist.github.com/netj/8836201) (b) Find confusion matrix and evaluation matrix for SVM		CO-2	-	80	20
3.	a) Explore k-means algorithm for the small sample dataset. b) Explore k-means algorithm for Iris Dataset		CO-2	20	70	10
4.	Apply EM algorithm to cluster a set of data stored in a .CSV file.Use the same data set for clustering using k-Means algorithm. Compare the results of these two algorithms and comment on the quality of clustering. You can add Python ML library classes/API in the program.		CO-2	-	80	20
5.	Build an Artificial Neural Network by implementing the Backpropagation algorithm and test the same using appropriatedata sets.		CO-4	10	70	20
6.	Implement the perceptron algorithm from scratch in python.		CO-4	10	70	20
7.	Write a programme to implement two dimension and three-dimension Tensor.		CO-5	-	80	20
8.	Write a programme to add and multiply two 4x4 matrix, you can Import "tens or flow" and "numpy".		CO-5	-	80	20
9.	Solve a classification problem on the Tens or flow playground.		CO-5	20	70	10
10.	Implement algorithm for linear regression in tens or flow		CO-2, CO-5	10	70	20

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to beprepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies: Different Instructional/ ImplementationStrategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Group Discussion, Portfolio Based Learning, Live Demonstrations in Classrooms, Lab, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

P) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	Computer Systems	Desktop Computers with i3 processor, 16 GB RAM, 512 GBHDD	S. No. 1 to 10
2.	Online Python IDE	https://www.online-python.com/	S. No. 1 to 10
3.	Jupyter Notebook	Download from https://jupyter.org/	S. No. 1 to 10
4.	Pip Python package manager	Download Pip 22.3 From https://pypi.org/project/pip/	S. No. 1 to 10
5.	Google colab	https://colab.research.google.com/github/tensorflow/docs/blob/master/site/en/tutorials/quickstart/beginner.ipynb#scrollTo=DUNzJc4jTj6G	S. No. 1 to 10
6.	Various modules, Libraries and Packages	Tens or flow, NumPy, Pandas, package	S. No. 1 to 10

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Machine Learning using Python	Manaranjan Pradhan, U Dinesh Kumar	Wiley, ISBN-10: 8126579900 ISBN-13: 978-8126579907
2.	Introduction to Machine Learning	Jeeva Jose	Khanna Book Publishing Co. (P) ltd, 2020. ISBN-10: 9389139066 ISBN-13: 978-9389139068
3.	Machine Learning for Dummies	John Paul Mueller and Luca Massaron, For Dummies,	For Dummies; 2nd edition, ISBN-10: 1119724015 ISBN-13: 978-1119724018
4.	Machine Learning	Rajeev Chopra	Khanna Book Publishing Co., 2021 ISBN-10: 9789386173423 ISBN-13: 978-9386173423
6.	Learn TensorFlow 2.0: Implement Machine Learning and Deep Learning Models with Python	Pramod Singh, Avinash manure	Apress, 978-1484255605 ISBN-10: 1484255607 ISBN-13: 978-1484255605
7	Artificial Intelligence: Concepts, **Techniques and Applications**	Alexis Keller	States Academic Press, **2022 ISBN-** 9781649649245
8	**Artificial Intelligence:** An Introduction	**Jacob** Pearson	Willford Press 2022 ISBN 9781682860911
9	**Fundamentals of** Machine Learning	Mia Williams	Willford Press 2022 ISBN 9781682860920
10	Artificial Intelligence: A Modern Approach	Emilia Stones	Larsen and Keller Education 2022 ISBN 9781641728525

(b) Online Educational Resources:

1. NPTEL Course: Introduction to Machine Learning, Prof. Balaraman Ravindran, IIT Madras
2. https://www.tensorflow.org/resources/learn-ml
3. https://www.tutorialspoint.com/tensorflow/index.htm
4. https://www.javatpoint.com/tensorflow
5. https://developers.google.com/machine-learning/crash-course/exercises

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested OER, before use by the students.

(c) Others:

Data Source:

- https://archive.ics.uci.edu/ml/machine-learning-databases/auto-mpg/
- https://archive.ics.uci.edu/ml/machine-learning-databases/iris/iris.data
- https://www.kaggle.com/arshid/iris-flower-dataset
- https://www.kaggle.com/rohankayan/years-of-experience-and-salary-dataset

S) Course Curriculum Development Team (NITTTR, Bhopal)

- Dr. Sanjay Agrawal (Coordinator)
- Dr. R. K. Kapoor (Co-coordinator)

******

A)	**Course Code**	: **2000605C/2000608C/2000611C**
B)	**Course Title**	: Internet of Things (Advance)
C)	**Pre- requisite Course(s)**	: IoT (Basics), Computer Networks
D)	**Rationale**	:

The rise and rise of IoT technologies is redefining business opportunities and process. This has led to a growing need to learn advance skills to remain competitive in the market. Put together, these are a potent combination of technologies that will dictate how our future is written, which is a strong indicator of rewarding job opportunities in those domains. Introduction of the Advanced IoT follows a rigorous curriculum which blends the academic excellence and industry-relevant applications.

This course will be exposed to a breadth of skills which will help students to become multi-faceted software engineers with a deeper understanding of these modern technologies, their applications, and interdependence.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

CO-1 Use basic Python features in Programming.

CO-2 Use advance Python features in Programming.

CO-3 Explain features of Cloud and IoT data storage on it.

CO-4 Explain IoT Networking and its application.

CO-5 Develop IoT App for the given problem

F) **Suggested Course Articulation Matrix (CAM):**

Course Outcomes (COs)	**Programme Outcomes (POs)**							**Programme Specific Outcomes* (PSOs)**	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	3	3	2	2	-	2	-		
CO-2	3	3	2	2	-	2	-		
CO-3	1	-	3	2	2	2	2		
CO-4	1	-	2	3	-	2	2		
CO-5	3	3	3	2	2	3	3		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

* PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Board of Study	Course Code	Course Title	Scheme of Study (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
	2000605 C/200060 8C/20006 11C	IoT (Advance)	03	-	04	02	09	05

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances/ problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCS, spoken tutorials, Online educational resources etc.

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Assessment Scheme:

Board of Study	Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
	2000605 C/20006 08C/200 0611C	IoT (Advance)	30	70	20	30	20	30	200

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- Separate passing is must for progressive and end semester assessment for both theory and practical.
- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

I) Course Curriculum Detailing: This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.1. a. Write the steps to install Python. TSO.1. b. Explain given types of variables in python. TSO.1.c. Explain use and importance of Tuple, Dictionary, operators in python TSO.1. d. Explain use of array in python. TSO.1. e. Explain use of 2-Dimensional Array in python TSO.1. f Explain uses of given type of Conditional statement in python.	**Unit-1.0 Python basics: -** 1.1 Installation of Python 1.2 Variables, Print () function, Escape character sequence and run python Program 1.3 Python Tuple, Dictionary, operators 1.4 Python arrays, create, reverse and append data into it. 1.5 Python 2 Dimensional arrays. 1.6 Python Conditional statement.	**CO-1 and CO-5**
TSO.2. a. Explain uses of given type of do & while loops in python TSO.2. b. Explain working of break, continue and pass statement in python TSO.2.c. Write the benefits of using OOP methodology in python. TSO.2.d.Explain given type of string operation related to python. TSO.2.e.Explain given function in python TSO.2.f Explain use of Lambda function in python.	**Unit 2. Python Advance: -** 2.1 Python Do & while loops 2.2 Python break, continue, pass statements 2.2 Python OOPs Class, Object, Inheritance and Constructor 2.4 Python Strings Replace, Join, Split, Reverse, Uppercase, Lowercase, count, find, split and length 2.5 Python Functions, Built-in functions and user defined functions 2.6 Lambda function and uses	**CO-1 and C05**
TSO.3.a. Differentiate between Cloud and IoT cloud. TSO.3.b. Explain features of Cloud in IoT environment TSO.3.c. List features of various types of Cloud TSO.3.d. List features of cloud services like SaaS, PaaS and IaaS TSO.3.f List advantages of cloud data storage. TSO.3.g Explain Arduino architecture and its applications. TSO.3.h Explain Raspberry pi architecture and its applications.	**Unit-3.0 Cloud features: -** 3.1 Cloud computing and IoT cloud 3.2 Benefits of cloud in IoT 3.3 Types of Cloud public, private and hybrid 3.4 Cloud services like SaaS, PaaS and IaaS 3.5 Cloud connectivity and Data storage on Cloud. 3.6 Arduino: Architecture, Programming, and Applications 3.7 Raspberry Pi Architecture, Programming, and Application basic level for IoT applications	**CO-1, CO-2 and CO-5**
TSO.4.a. Explain wired network TSO.4.b.Explain short range wireless network TSO.4.c.Explain M2M communication TSO.4.d.Explain various generation of wireless network TSO.4.e.Explain the importance of LWPAN in IoT TSO.4.f Differentiate between SigFox & LoRaWAN TSO.4.g Explain use of NB-IOT (Narrow Band IOT) TSO.4.h Create heterogenous network using RFID.	**Unit.4 IoT Networking and Application: -** 4.1 Wired and short-range wireless network 4.2 M2M – 2G, 3G, 4G & 5G networks 4.3 LPWAN – Low Power Wide Area Networks 4.4 SigFox & LoRaWAN. 4.5 NB-IOT (Narrow Band IOT) 4.6 RFID and Bar code basics- Components of an RFID system-Data -Tags-Antennas- Connectors- Cables- Readers- encoder/ printers for smart labels- Controllers software 4.7 RFID advantages over Bar codes.	**CO-1 and CO-4**
TSO.5.a. Identify suitable framework for IoT app development	**Unit. 5 IoT App Development**: - 5.1 Framework selection for IoT app development	**CO-4 and CO-5**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.5.b. Identify various stages of selected app TSO.5.c. Develop the app. TSO.5.d. Implement and deploy the app TSO.5.e Maintain and improve the app based on the feedback	5.2 Identify stages of app to be developed. 5.3 Develop, Implement, and Deploy the App 5.4 Testing and Integration 5.5 Maintain and improve	

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical (2000608C):

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSOs 1.1 Python installation LSOs 1.2 Prepare and run python program on given problem LSOs 1.3 Prepare python program on Dictionary, Tuple and operators. LSOs 1.4 Prepare program on arrays LSOs 1.5 Prepare a program on 2-dimensional array LSOs 1.6 Create program on conditional statement	1.	1.1 Install given version of Python on the computer system. 1.2 Prepare a python program using print() function and run it. 1.3 Access given value from the tuple 1.4 Print the given value of key from the dict. 1.5 Write a Python program to create an array of 5 integers and display the array items. Access individual element through indexes 1.6 Write a Python program which takes two digits m (row) and n (column) as input and generates a two-dimensional array. 1.7 Write a python program to check whether person is eligible for voting or not. (accept age from the user) 1.8 Write a python program to check whether the entered number is even or odd. 1.9 Write a python program to check whether entered number is divisible by another entered number. 1.10 Write a python program to display "Yes" is entered number is divisible by 5 otherwise display "No"	**CO-1**
LSOs 2.1 Prepare python program on Do & while loops LSOs 2.2 Prepare python program on break and continue statement. LSOs 2.3 Prepare Python program using break and continue statements LSOs 2.4 prepare python program using OOP LSOs 2.5 Prepare Python program using functions	2.	2.1 Prepare a python program which can print first 10 even and odd numbers using while statement 2.2 Write a python program which can print first 10 integers and its square using while/for loop. 2.3 Write a python program which can print sum of first 10 natural numbers using while/for loop. 2.4 Write a python program which can identify the prime number between the range given using while/for loop. 2.5 Consider a situation where you want to iterate over a string and want to print all the characters until a letter 'e' or 's' is encountered. It is specified	**CO-2**

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
		that you have to do this using loop and only one loop is allowed to use. 2.6 Consider the situation when you need to write a program which prints the number from 1 to 10 and but not 6. It is specified that you have to do this using loop and only one loop is allowed to use. 2.7 Create a Class with instance attributes 2.8 Create a Vehicle class without any variables and methods 2.9 Write a Python function to find the Max of three numbers. 2.10 Write a Python program to reverse a string.	
LSO 3.1 Signup for free cloud storage LSO 3.2 Store data into cloud and retrieve it.	3.	3.1 Create a free cloud account 3.2 Store data on cloud and retrieve it	**CO-3**
LSO 4.1 Design various types of network cables LSO 4.2 Connect computer in LAN. LSO 4.3 Connect devices using wireless network LSO 4.4 Connect machine with machine LSO 4.5 Connect devices using IEEE 802 LSO 4.6 Connect devices using LPWAN LSO 4.7 Connect devices using RFID	4	4.1 Study of different types of Network cables and Practically implement the cross-wired cable and straight through cable using clamping tool. 4.2 Connect the computers in Local Area Network 4.3 Connect 2 or more devices using Bluetooth 4.4 Connect 2 or more devices using infrared 4.5 Connect 2 more machine using m2m 4.6 Connect 2 or more different devices using access point 4.7 Connect 2 devices using LPWAN (Smart Meter) 4.8 Connect 2 or more devices using RFID	**CO-4**
LSO 5.1 Develop a IoT app LSO 5.2 Develop IoT applications using smartphones.	5.	5.1 Identify a problem and develop an app 5.2 Building a temperature monitoring system using sensors and Smartphone	**CO-5**

L) Suggested Term Work and Self Learning (2000611C): Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. Assignments: Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

b. Micro Projects:

1. Prepare a report on Python programming language.
2. Develop a small software in python to solve a IoT data analysis.
3. Create a id on free cloud storage and share data on it for others.
4. Create a heterogenous network and connect different dives.
5. Create a an IoT app for the identified problem

c. Other Activities:

1. Seminar Topics: - “Future of wireless network.”

2. “Smart electricity billing “, “Cloud computing and IoT”
3. Visit to industry for IoT implementation in industrial process.
4. Reading RFID cards using 8051- RFID in the supply chain- Vehicles parking using RFID- library management system- electronic toll payment- smart shipping containers fleet monitoring and management.
5. Building IoT Applications like pressure, air quality, temperature and motion detector using Arduino and raspberry-pi Universal boards.
6. Surveys of market for availability of various types of network devices and its pricing.
7. Product Development: Development of projects for real life problem solution app.
8. Software Development: Using Python

d. Self-learning topics:

1. Deeper knowledge in Python features
2. Network devices and its capabilities
3. Advantages of IoT implementations

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

<table>
<tr><th rowspan="4">COs</th><th colspan="7">Course Evaluation Matrix</th></tr>
<tr><th colspan="2">Theory Assessment (TA)**</th><th colspan="3">Term Work Assessment (TWA)</th><th colspan="2">Lab Assessment (LA)#</th></tr>
<tr><th rowspan="2">Progressive Theory Assessment (PTA)
Class/Mid Sem Test</th><th rowspan="2">End Theory Assessment (ETA)</th><th colspan="3">Term Work & Self-Learning Assessment</th><th rowspan="2">Progressive Lab Assessment (PLA)</th><th rowspan="2">End Laboratory Assessment (ELA)</th></tr>
<tr><th>Assignments</th><th>Micro Projects</th><th>Other Activities*</th></tr>
<tr><td>CO-1</td><td>10%</td><td>10%</td><td>20%</td><td>--</td><td>33%</td><td>10%</td><td>20%</td></tr>
<tr><td>CO-2</td><td>15%</td><td>10%</td><td>20%</td><td>--</td><td>33%</td><td>15%</td><td>20%</td></tr>
<tr><td>CO-3</td><td>30%</td><td>30%</td><td>20%</td><td>--</td><td>34%</td><td>15%</td><td>20%</td></tr>
<tr><td>CO-4</td><td>20%</td><td>30%</td><td>20%</td><td>50%</td><td>--</td><td>30%</td><td>20%</td></tr>
<tr><td>CO-5</td><td>25%</td><td>20%</td><td>20%</td><td>50%</td><td>--</td><td>30%</td><td>20%</td></tr>
<tr><td rowspan="2">Total Marks</td><td rowspan="2">30</td><td rowspan="2">70</td><td>20</td><td>20</td><td>10</td><td rowspan="2">20</td><td rowspan="2">30</td></tr>
<tr><td colspan="3">50</td></tr>
</table>

Legend:

***:** Other Activities include self-learning, seminar, visits, surveys, product development, software development etc.

******: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1. Python basics	5	CO1	7	2	2	3
Unit-2. Python Advance	5	Co1, CO2	7	2	2	3
Unit-3. Cloud features	14	CO3	21	8	8	5
Unit-4. Networking and Application	14	CO4, C03	21	5	7	9
Unit-5. IoT Applications	10	CO5, CO3 and CO4	14	3	6	5
Total Marks	**48**		**70**	**20**	**25**	**25**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

SN	Laboratory Practical Titles	Relevant COs Number(s)	PLA /ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Install given version of Python the computer system.	CO-1	70	20	10
2.	Prepare a python program using print() function and run it.	CO-1	60	30	10
3.	Access given value from the tuple	CO-1	60	30	10
4.	Print the given value of key from the dict.	CO-1	60	30	10
5.	Write a Python program to create an array of 5 integers and display the array items. Access individual element through indexes	CO-1	60	30	10
6.	Write a Python program which takes two digits m (row) and n (column) as input and generates a two-dimensional array.	CO-1	60	30	10
7.	Write a python program to check whether person is eligible for voting or not. (accept age from the user)	CO-1	60	30	10
8.	Write a python program to check whether the entered number is even or odd.	CO-1	60	30	10
9.	Write a python program to check whether entered number is divisible by another entered number.	CO-1	60	30	10
10.	Write a python program to display “Yes” is entered number is divisible by 5 otherwise display “No”	CO-1	60	30	10
11.	Prepare a python program which can print first 10 even and odd numbers using while statement	CO-2	60	30	10
12.	Write a python program which can print first 10 integers and its square using while/for loop.	CO-2	60	30	10

SN	Laboratory Practical Titles	Relevant COs Number(s)	PLA /ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
13.	Write a python program which can print sum of first 10 natural numbers using while/for loop.	CO-2	60	30	10
14.	Write a python program which can identify the prime number between the range given using while/for loop.	CO-2	60	30	10
15.	Consider a situation where you want to iterate over a string and want to print all the characters until a letter 'e' or 's' is encountered. It is specified that you have to do this using loop and only one loop is allowed to use.	CO-2	60	30	10
16.	Consider the situation when you need to write a program which prints the number from 1 to 10 and but not 6. It is specified that you have to do this using loop and only one loop is allowed to use.	CO-2	60	30	10
17.	Create a Class with instance attributes	CO-2	60	30	10
18.	Create a Vehicle class without any variables and methods	CO-2	60	30	10
19.	Write a Python function to find the Max of three numbers.	CO-2	60	30	10
20.	Write a Python program to reverse a string.	CO-2	60	30	10
21.	Create a free cloud account	CO-3	70	20	10
22.	Store data on cloud and retrieve it.	CO-3	60	30	10
23.	Study of different types of Network cables and Practically implement the cross-wired cable and straight through cable using clamping tool.	CO-4	70	20	10
24.	Connect the computers in Local Area Network	CO-4	70	20	10
25.	Connect 2 or more devices using Bluetooth	CO-4	70	20	10
26.	Connect 2 or more devices using infrared	CO-4	70	20	10
27.	Connect 2 more machine using m2m	CO-4	70	20	10
28.	Connect 2 or more different devices using access point	CO-4	70	20	10
29.	Connect 2 devices suing LPWAN (Smart Meter)	CO-4	70	20	10
30.	Connect 2 or more devices using RFID	CO-4	70	20	10
31.	Identify a problem and develop an app	CO-5	70	20	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) **Suggested Instructional/ Implementation Strategies:** Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1	Python software	Openly available as per instruction	As mentioned above list
2	Cables connecters and crimping tools	Cat 6e cable, RJ-45 connectors and Crimping Tool	
3	Bluetooth and infrared devices	Any mobile and wireless keyboard and mouse	
4	IoT free cloud	Free available	
5	Smart devices	Like meters, bulbs etc.	
6	Wireless access point	Wireless router or access point	
8	Arduino development board	Arduino Uno and Arduino Nano.	
6	Raspberry Pi	Raspberry Pi 4/ Raspberry Pi 3/ Raspberry Pi 2	

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1	Let Us Python	Kanetkar Yashavant	BPB Publications ISBN: 9789388511568, 9789388511568
2	IOT (Internet of things) and Its Application	P K Pandey	T Balaji Publication (1 January 2020) ISBN-10: 8194136385 ISBN-13: 978-8194136385
3	Raspberry Pi Cookbook: Software and Hardware Problems and Solutions	Simon Monk	Shroff/O'Reilly; Third edition (4 October 2019) ISBN-10: 9352139267 ISBN-13: 978-9352139262
4	Raspberry Pi Cookbook: Software and Hardware Problems and Solutions,	Simon Monk	Shroff/O'Reilly; Third edition (4 October 2019) ISBN-10: 9352139267 ISBN-13: 978-9352139262
5	Cloud Computing: Concepts, Technology & Architecture	Erl	Pearson Education India; 1st edition (1 January 2014) ISBN-10: 9332535922 ISBN-13: 978-9332535923
6.	Fundamentals of Internet of Things	Eden Scott	States Academic Press 2023 ISBN 9781649649235

7	Internet of Things	Alaina Wilson	Murphy & Moore Publishing 2023 ISBN 9781649872731
8	Principles of Internet of Things	Hallie Parker	Larsen and Keller Education 2023 ISBN 9781641728312

(b) Online Educational Resources:

1. nptel.iitm.ac.in/courses/.../IIT.../lecture%2023%20and%2024.htm
2. en.wikipedia.org/wiki/Shear_and_moment_diagram
3. www.freestudy.co.uk/mech%20prin%20h2/stress.pdf
4. www.engineerstudent.co.uk/stress_and_strain.html
5. https://www.iit.edu/arc/workshops/pdfs/Moment_Inertia.pdf
6. https://www.veritis.com/blog/aws-vs-azure-vs-gcp-the-cloud-platform-of-your-choice/
7. https://wiki.python.org/moin/TimeComplexity
8. www.engineerstudent.co.uk/stress_and_strain.html
9. https://www.iit.edu/arc/workshops/pdfs/Moment_Inertia.pdf
   Amini, P. (2014). Sulley: Pure Python fully automated and unattended fuzzing frame- work. https://github.com/OpenRCE/sulley

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested OER, before use by the students.

(c) Others:

1. Learning Packages
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

S) Course Curriculum Development Team (NITTTR, Bhopal)

Dr. M. A. Rizvi (Coordinator)

******

A) **Course Code** : **2000605D/2000608D/2000611D**

B) **Course Title** : Drone Technology (Advanced)

C) **Pre- requisite Course(s)** : Drone Technology (Basics)

D) **Rationale** :

In previous semester, a course in drone technology broadly discussed about basic principles, functions and interface of different components and design simple drone structure. In order to understand the successive development of drones / UAVs in terms of their geometric structure, working methodology and navigation control etc., so it is important to study the advanced course on Drone Technology. This course includes the study of Static and dynamic force analysis on drone, advance flying features, navigation control, maintenance and advance applications of different types of drone.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

CO-1 Apply the concept of engineering mechanics for stability of drone.

CO-2 Design the structure of drone using GPS module and thermal Image camera.

CO-3 Operate drone using advance flight controller board.

CO-4 Perform drone maintenance and assembly.

CO-5 Use drone in advance applications like precision agriculture, security, IoT, etc.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	3	-	-	-	-	-	-		
CO-2	2	2	-	3	3	-	-		
CO-3	2	2	3	3	-	-	-		
CO-4	3	-	-	3	-	-	-		
CO-5	-	2	2	-	-	3	2		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

* PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Board of Study	Course Code	Course Title	Scheme of Study (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
	2000605D/2000608D/2000611D	Drone Technology (Advance)	03	-	04	02	09	05

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Assessment Scheme:

Board of Study	Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
	2000605D/20006 08D/2000611D	Drone Technology (Advance)	30	70	20	30	20	30	200

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- Separate passing is must for progressive and end semester assessment for both theory and practical.
- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

I) Course Curriculum Detailing: This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 1a. Draw free body diagram of quadcopter drone. TSO 1b. Determine centroid of given drone structure. TSO 1c. Determine center of gravity of different drone structure. TSO 1d. Analyze different types of force acting drone system. TSO 1e. Differentiate between static and dynamic force analysis. TSO 1f. Explain how gyroscopic motion keeps drone balanced and hovering.	**Unit-1.0 Engineering mechanics for Drone technology** 1.1 Drone Mechanics • Free body diagram of drone • Method of finding resultant of force system • Equilibrium of coplanar force system 1.2 Center of Gravity • Centroid of plane figure • Center of gravity of solid bodies 1.3 Force analysis in drone • Force analysis in drone • Forces of flight • Principle axes and rotation of aerial systems 1.4 Dynamics of machine • Static and dynamic force analysis • Gyroscopic motions	**CO-1**
TSO 2a. Describe properties and application of smart materials use in UAV frame. TSO 2b. Calculate the diameter of the propeller for given drone frame size. TSO 2c. Determine size of quadcopter frame and diameter of propeller of drone TSO 2d. Describe working of GPS and its hardware interfacing. TSO 2e. Write steps to interface GPS module for drone navigation. TSO 2f. Describe different RF blocks and antennas used in RF transmitter and receiver.	**Unit-2.0 Drone Frame and components** 2.1 Drone frame design • Calculation principle for drome frame sizes • Quadcopter frame design • Smart materials for UAV frame • Green material uses in drone 2.2 Advance Drones component • GPS, Interfacing of GPS hardware • Thermal and chemical sensor • Tilt and LiDAR sensor 2.3 RF transmitter and receiver • RF blocks • RF antennas 2.4 Micro-electromechanical systems (MEMS) based sensor 2.5 HD and thermal Image camera	**CO-2**
TSO 3a. Identify features and specifications of FCB use in different application	**Unit-3.0 Advance flight controller Board (FCB)**	**CO-3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 3b. Explain ports of any given advance flight controller board. TSO 3c. Write steps of software installation of flight controller board. TSO 3d. Describe installation and calibration steps of radio telemetry with FCB. TSO 3e. Write steps of calibration of accelerometer and ESC with FCB. TSO 3f. Describe interfacing of GPS with FCB.	3.1 Specification and ports of FCB 3.2 Software for FCB • Software installation 3.3 Radio Communication with FCB • Installation of Radio Telemetry • Radio Calibration with FCB 3.4 Calibration of accelerometer 3.5 Calibration of ESC 3.6 Interface of motor with FCB using ESC 3.7 GPS interface with FCB 3.8 Safety features of advance FCB	
TSO 4a. Describe challenges comes in drone maintenance. TSO 4b. Describe measuring devices and instrument use in drone maintenance. TSO 4c. Describe measuring instrument used to measure electrical parameters in drone. TSO 4d. Write sequence of steps use in assembling of drone.	**Unit-4.0 Maintenance and assembling of Drone** 4.1 Need and scope of drone maintenance 4.2 Types of maintenance 4.3 Routine drone maintenance and its checklist • Recording basic details • Structural inspection • Battery check • Software/firmware 4.4 Types of measuring instrument use in drone maintenance 4.5 Measurement of different electrical parameters related with drone hardware 4.6 Assembly of drones • Concept of interchangeability • Principle of gauging and their applicability in drone assembly • Parameters and profile measurements of standard propellers • Concepts of drone assembly using 3D modeling	**CO-4**
TSO 5a. Describe function of autonomous drone using AI. TSO 5b. Describe IoT enable UAV for surveillance and data gathering. TSO 5c. Explain drone applications based on cost saving, enhanced efficiency and profitability aspects.	**Unit-5.0 Advance Drone Application** 5.1 Application of AI in Drone Technology 5.2 IoT and Computer vision integrated Drone 5.3 Drone interface with smart-phone 5.4 Drone Applications in • Military • Precision Agriculture	**CO-5**

Note: One major TSO may require more than one theory session/period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical (2000608D):

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Use the force of gravity to compute the centre of gravity for a given drone structure.	1.	Determine Centre of gravity of different done structure.	**CO-1**
LSO 2.1 Develop skills of observation and interpreting phenomenal changes on Drone model for stability and hovering.	2.	Demonstrate gyroscopic effect on a drone model	**CO-1**
LSO 3.1 Draw various frame to be required in designing drone structure. LSO 3.2 Use Measuring instrument in designing drone frame. LSO 3.3 Choose suitable materials for making drone frame	3.	Compare different types of airframe structure like quadcopter frame (plus shape, cross shape and H-shape), hexacopter frame (hexa + and hexa S).	**CO-2, CO-4**
LSO 4.1 Identify and measure the condition of sensors. LSO 4.2 Interface Tilt and LiDAR sensors in drone.	4.	Test Tilt and LiDAR sensors and their characteristics with Microcontroller based Flight controller board.	**CO-2**
LSO 5.1 Identify different component of GPS module LSO 5.2Measure and use signals from GPS module to determine latitude & longitude. LSO 5.3 Diagnose problems using appropriate instruments/tools related to GPS navigation.	5.	Demonstrate the interfacing of GPS module to drone navigation.	**CO-2, CO-3**
LSO 6.1 Measure characteristics of HD and thermal Image camera. LSO 6.2 Diagnose common problems related to HD and thermal Image camera.	6.	Test HD and thermal Image camera and their characteristics.	**CO-2**
LSO 7.1 Identify the characteristics of RF circuit blocks like amplifier, and filters. LSO 7.2 Identity different antennas used. LSO 7.3 Operate drone using RC transmitter and receiver.	7.	Identify, configure and operate 433MHz and 2.4 GHz RC transmitter and receiver.	**CO-2**
LSO 8.1 Test the different peripheral interconnections with FCB LSO 8.2 Troubleshoot advance Flight control board (FCB)	8.	Programming and configure of parameters in flight control board (FCB).	**CO-3**
LSO 9.1 Configure radio communication device to control drones. LSO 9.2 Operate drone using RC transmitter and receiver.	9.	Test and perform communication of advance Flight control board with RF transceiver.	**CO-3, CO-2**
LSO 10.1 Measure various parameters of GPS system LSO 10.2 Interface GPS system with flight controller board.	10.	Test and perform communication of Flight control board (FCB) with GPS	**CO-3, CO-2**
LSO 11.1 Configure HD and thermal image camera with drone. LSO 11.2 Demonstrate use of HD and thermal image camera with FCB	11.	Test and troubleshoot HD and thermal image camera with advance FCB in drone.	**CO-3, CO-2**
LSO 12.1 Measure voltage, current frequency using Digital Multimeter LSO 12.2 Measure peak to peak voltage, time period, and duty cycle using DSO and waveform generator.	12.	Measure various electric parameters in drone hardware	**CO-4**

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 12.3 Measure unknown frequency and its level using spectrum analyzer.			
LSO 13.1 Inspect drone as per the given checklist LSO 13.2 Diagnose drone problems after flying of 50 and 100hrs	13.	Perform preventive maintenance of drone components	**CO-4**
LSO 14.1 Perform dismantle process of drone. LSO 14.2 perform services need for operation LSO 14.3 Check and Install different parts of the drone system. LSO 14.4 Assemble drone component.	14.	Dismantle and service of different parts of drone system	**CO-4**

L) Suggested Term Work and Self Learning (2000611D): Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. Assignments: Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

b. Micro Projects:

1. Prepare maintenance report for small UAV.
2. Survey nearby electronics shop and Prepare report on types of drone frames and drone sensors available and its specification.
3. Prepare report of surveying & mapping of our institute using drone with HD and thermal image camera.
4. Prepare report on land and crops quality of nearby agriculture field using drone.
5. Prepare report on Identify and select different application drones like agriculture, Surveillance, Inspections and gathering Information for disaster management.
6. Download 5 videos on advance FCB of drone design. Watch them and write report on it.
7. Market survey on different types of FCB, its specification and specific application and prepare report.
8. Develop mission completion drone with the help of GPS based Advance FCB.

c. Other Activities:

1. Seminar Topics-Drone stability using gyroscopic motion, Quadcopter frame, Green material use in drone design, GPS based drones, types of HD and thermal Image camera, Safety features in advance drone, Drone Assembling, Military drone.
2. Visits: Visit nearby small industry, Drone institute facilities. Prepare report of visit with special comments of advance drone technology used, material used, cost of printed component.
3. Surveys: Survey nearby electronics shop and Prepare report of list of advance drone components and its specification.
4. Product Development
5. Software Development

d. Self-learning topics:

1. Different types Drones frame
2. Overview of GPS technology
3. Different types of HD and thermal Image camera
4. Safety features in Drone
5. Advance drone application

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self-Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	15%	15%	20%	20%	20%	25%	25%
CO-2	20%	20%	20%	20%	20%	25%	25%
CO-3	25%	25%	20%	20%	20%	25%	25%
CO-4	25%	25%	20%	20%	20%	25%	25%
CO-5	15%	15%	20%	20%	20%	-	-
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

***:** Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

****:** Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit 1.0 Engineering mechanics for Drone Technology	8	**CO-1**	12	04	04	04
Unit 2.0 Drone frame and components	10	**CO-2**	14	04	04	06
Unit 3.0 Advance Flight Controller Board	12	**CO-3**	16	04	06	06
Unit 4.0 Maintenance and assembling of drone	10	**CO-4**	16	04	06	06
Unit 5.0 Advance Drone Application	8	**CO-5**	12	04	04	04
Total Marks	**48**		**70**	**20**	**24**	**26**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA /ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Determine Centre of gravity of different done structure.	CO-1	50	40	10
2.	Demonstrate gyroscopic effect on a drone model	CO-1	40	50	10
3.	Compare different types of airframe structure like quadcopter frame (plus shape, cross shape and H-shape), hexacopter frame (hexa + and hexa S).	CO-2	50	40	10
4.	Test Tilt and LiDAR sensors and their characteristics with Microcontroller based Flight controller board.	CO-2	50	40	10
5.	Demonstrate the interfacing of GPS module to drone navigation.	CO-2, CO-3	50	40	10
6.	Test HD and thermal Image camera and their characteristics.	CO-2	50	40	10
7.	Identify, configure and operate 433MHz and 2.4 GHz RC transmitter and receiver.	CO-2	60	30	10
8.	Programming and configuration of parameters in flight control board (FCB).	CO-3	60	30	10
9.	Test and perform communication of advance Flight control board with RF transceiver.	CO-3, CO-2	60	30	10
10.	Test and perform communication of Flight control board (FCB) with GPS	CO-3, CO-2	60	30	10
11.	Test and troubleshoot HD and thermal image camera with advance FCB in drone.	CO-3, CO-2	60	30	10
12.	Measure various electric parameters in drone hardware	CO-4	40	50	10
13.	Perform preventive maintenance of drone components	CO-4	60	30	10
14.	Dismantle and service of different parts of drone system	CO-4	60	30	10

Legend:
PRA*: Process Assessment
PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies:

Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	Drone Frame	Tricopter/Quadcopter/Hexacopter	1-15
2.	Propellers	15 X 5.5 CW/Others	1-15
3.	GPS module	M8N Series	1-15
4.	Drone Camera	15-20 Megapixel	1-15
5.	Camera Gimble	3 Axis feature, 360 Degree movement	1-15
6.	Tilt Sensor	8-30 volt	1-15
7.	LiDER sensor	Range 75m to 200m	1-15
8.	Battery	Lithium Polymer Battery,8000 to 10000 mAh	1-15
9.	Motor	BLDC, 370kv	1-15
10.	Electronic speed Controller (ESC)	40 Amp	1-15
11.	Flight Controller Board	CC3D/Pixhawk/Others	1-15
12.	Transmitter and Receiver for radio signal	10 Channels and more, 2.4 GHz & 5.8 GHz	1-15
13.	Embedded system for AI application on UAV	Open Source Jetson Baseboard /Others	1-15

R) Suggested Learning Resources:

(a) Books:

S. No.	Title s	Author (s)	Publisher and Edition with ISBN
1.	Make: DIY Drone and Quadcopter Projects: A Collection of Drone-Based Essays, Tutorials, and Projects	Editors of Make	Shroff/Maker Media, First edition 2016,ISBN-978-9352133994
2.	Make: Getting Started with Drones: Build andCustomize Your Own Quadcopter	Terry Kilby & BelindaKilby	Shroff/Maker Media, First edition 2016,ISBN-978-9352133147
3.	Agricultural Drones: A Peaceful Pursuit	K R Krishna	Apple Academic Press,1st edition 2018,ISBN-978-1771885959
4.	Building Multicopter Video Drones: Build and fly multicopter drones to gather breathtaking video footage	Ty Audronis	Packt Publishing Limited; Illustrated edition,2014, ISBN-978-1782175438
5.	The Complete Guide to Drones	Adam Juniper	Ilex Press, Extended 2nd Edition,2018ISBN-9781781575383
6.	Unmanned Aircraft Systems - UAVS Design, Development and Deployment (Aerospace Series)	R Austin	John Wiley & Sons Inc, 1st edition, 2010,ISBN-978-0470058190
7	Drone Technology	Miranda Hall	NY Research Press 2023 ISBN 9781632389574

8	Introduction to UAV Systems	Rupert Baker	Willford Press 2023 ISBN 9781682860890
9	Theory, Design, and Applications of Unmanned Aerial Vehicles	Tyler Wood	Larsen and Keller Education 2023 ISBN 9781641728338

(b) Online Educational Resources:

1. https://archive.nptel.ac.in/courses/101/104/101104083/
2. https://onlinecourses.nptel.ac.in/noc21_ae14/preview
3. https://en.wikipedia.org/wiki/Unmanned_aerial_vehicle
4. https://fusion.engineering/
5. https://robocraze.com/blogs/post/best-flight-controller-for-drone
6. https://www.youtube.com/watch?v=lrkFG7GilPQ
7. https://www.youtube.com/watch?v=KjG6FKCNCbM
8. https://ardupilot.org/
9. https://px4.io/

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

(c) Others:

1. Development of an Autonomous IoT-Based Drone for Campus Security, Abdelrahman Mahmoud Gaber, Rozeha A. Rashid, Nazri Nasir, Ruzairi Abdul Rahim, M. Adib Sarijari, A. Shahidan Abdullah, Omar A. Aziz, Siti Zaleha A. Hamid, Samura Ali,2021
2. IoT based UAV platform for emergency services; S. K. Datta, J. L. Dugelay, & C. Bonnet, 2018
3. Development of an Autonomous Drone for Surveillance Application; M. A. Dinesh, S. Santhosh Kumar, J. Sanath, K. N. Akarsh & K. M. Manoj Gowda,2018
4. Autonomous cloud-based drone system for disaster response and mitigation; C. Alex & A. Vijaychandra,2016
5. https://www.geeetech.com/Documents/CC3D%20flight%20control%20board.pdf
6. https://www.bhphotovideo.com/lit_files/201146.pdf
7. http://tricopter.hu/docs/cc3d_manual.pdf

S) Course Curriculum Development Team (NITTTR, Bhopal)

- Dr. K. K. Jain (Coordinator)
- Dr. Sanjeet Kumar (Co-coordinator)

******

A) **Course Code** : **2000605E/2000608E/2000611E**

B) **Course Title** : 3D Printing and Design (Advance)

C) **Pre- requisite Course(s)** : 3D Printing and Design (Basic)

D) **Rationale** :

This advanced course on 3D Printing tries to develop understanding of the process of making real complex objects from digital models in the students using various 3D printing processes and materials (Plastics, Ceramics and Metals). It also covers the post processing required and details about various printing process and parameters to make a quality 3D printed component. This course can only be taken up after completing 3D Printing and Design (Basic) course offered in previous semester.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

CO-1 Select newer 3D Printing material for various applications.
CO-2 Use solid based 3D Printing processes to develop products.
CO-3 Use liquid-based 3D Printing processes to develop products.
CO-4 Use powder-based 3D Printing processes to develop products.
CO-5 Apply post processing techniques and quality checks on 3D printed components.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	3	-	-	-	2	-	2		
CO-2	3	-	2	2	-	-	2		
CO-3	3	-	2	2	-	-	2		
CO-4	3	-	2	2	-	-	2		
CO-5	3	2	-	3	2	-	2		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

* PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Board of Study	Course Code	Course Title	Scheme of Study (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
	2000605E /2000608E /2000611E	3D Printing and Design (Advanced)	03	-	04	02	09	05

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Assessment Scheme:

Board of Study	Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
	2000605E /2000608E /2000611E	3D Printing and Design (Advanced)	30	70	20	30	20	30	200

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- Separate passing is must for progressive and end semester assessment for both theory and practical.
- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

I) Course Curriculum Detailing: This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self-Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain various forms of 3D printing raw material. *TSO 1b.* Select material for the given popular 3D printing processes with justification. *TSO 1c.* Select various Polymer based 3D printing raw materials with justification. *TSO 1d.* Explain procedure of Powder preparation for the given 3D printing material. *TSO 1e.* Explain properties of the given Metal/Ceramics 3D printing material. *TSO 1f.* Choose suitable 3D printing material on the basis of Performance Requirements and Material Properties.	**Unit-1.0 3D Printing Materials** 1.1 Various forms of 3D printing raw material- Liquid, Solid, Wire, Powder. 1.2 Popular FDM, SLA, SLS, Binder Jetting, Material Jetting and Direct Energy deposition 3D printing materials. 1.3 Polymers, Metals, Non-Metals, Ceramics. 1.4 Polymers and their properties. 1.5 Powder Preparation and their desired properties. 1.6 Choosing the Right 3D Printing Material on the basis of Performance Requirements and Material Properties.	**CO1**
TSO 2a. Explain working of a typical FDM based 3D Printer. *TSO 2b.* Justify use of FDM based 3D printing process and material for the given component. *TSO 2c.* Explain the Laminated Object Manufacturing process. *TSO 2d.* Estimate the cost and time of the given FDM based 3D printed component.	**Unit-2.0 Solid based 3D Printing Processes** 2.1 Basic principle and working of fused deposition modeling (FDM) process. 2.2 Liquefaction, solidification and bonding. 2.3 Laminated Object Manufacturing process. 2.4 Cost estimation of FDM 3D printed component.	**CO1, CO2**
TSO 3a. Explain the phenomenon of Photo Polymerization. *TSO 3b.* Explain the working of a typical Stereo Lithography based 3D Printer. *TSO 3c.* Explain procedure of 3D Scanning of the given component. *TSO 3d.* Justify use of SLA based 3D printing process and material for the given component. *TSO 3e.* Estimate the cost and time of the given SLA based 3D printed component. *TSO 3f.* Apply Curing process to SLA based 3D printed component.	**Unit-3.0 Liquid based 3D Printing Processes** 3.1 Photo polymerization. 3.2 Principle and working of stereo lithography apparatus. 3.3 SLA based 3D printing processes. 3.4 SLA based 3D printing process materials. 3.5 Scanning techniques. 3.6 Curing processes. 3.7 Cost estimation of SLA 3D printed component.	**CO1, CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 4a. Explain powder fusion mechanism. *TSO 4b.* Explain working of a typical SLA based 3D Printer. *TSO 4c.* Justify use of SLA based 3D printing process and material for the given component. *TSO 4d.* Explain Net shape process. *TSO 4e.* Explain Binder Jet 3D printing process. *TSO 4f.* Justify use of Binder Jet 3D printing process and material for the given component. *TSO 4g.* Estimate the cost and time of the given SLS based 3D printed component.	**Unit-4.0 Powder based 3D Printing Processes** 4.1 Powder fusion mechanism. 4.2 Principle and working of Selective Laser Sintering (SLS) process. 4.3 SLS based 3D printers. 4.4 Laser Engineering Net Shaping process. 4.5 Electron Beam Melting. 4.6 Binder Jet 3D Printing. 4.7 Materials and Process parameters for SLS based 3D printing processes. 4.8 Cost estimation of SLS based 3D printed component.	**CO1, CO4**
TSO 5a. Justify the need of post processing in the given 3D printed component. *TSO 5b.* List the various post processing techniques. *TSO 5c.* List the steps to perform post processing. *TSO 5d.* Explain the given Cleaning related post processing approach for 3D printed component. *TSO 5e.* Explain the given Surface finishing related post processing approach for 3D printed component. *TSO 5f.* Apply simple inspection and testing techniques on the given 3D printed component. *TSO 5g.* Identify the type of defect(s) in the given 3D printed component.	**Unit-5.0 Post Processing and Quality** 5.1 Need of post processing: Functional and Aesthetic reasons. 5.2 Steps of Post Processing: Cleaning/Support removal, Fixing, Curing or hardening, Surface finishing, Colouring. 5.3 Cleaning: Support Removal (FDM and Material Jetting); Powder Removal (SLS and Powder Bed Fusion); Washing (SLA and Photo polymerisation). 5.4 Fixing: Filling, Gluing, Welding. 5.5 Surface finishing: Sanding, Polishing, Tumbling, Hydro dipping, Epoxy coating, Electro Plating, Vapour smoothing-Acetone treatment. 5.6 Colouring, Coating, Priming and Painting. 5.7 Inspection and testing: Digital, Visual, Physical. 5.8 Defects and their causes.	**CO1, CO2, CO3, CO4, CO5**

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical (2000608E):

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1. Use the available 3D printing software. *LSO 1.2.* Select printing process parameters based on the type/make of Printer and raw material *LSO 1.3.* Set printing process parameters. *LSO 1.4.* Produce a complex component using available FDM Printer.	1.	Develop the assigned digital single complex component using FDM based 3D Printer and available material.	**CO1, CO2**
LSO 2.1. Use the available 3D printing software. *LSO 2.2.* Select printing process parameters based on the type/make of Printer and raw material *LSO 2.3.* Set printing process parameters. *LSO 2.4.* Produce a complex component using	2.	Develop the assigned digital single complex component using SLA based 3D Printer and available material.	**CO1, CO3**

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
available SLA Printer. *LSO 2.5.* Perform curing of the SLA based 3D printed component.			
LSO 3.1. Use the available 3D printing software. *LSO 3.2.* Select printing process parameters based on the type/make of Printer and raw material *LSO 3.3.* Set printing process parameters. *LSO 3.4.* Produce a complex component using available SLS Printer.	3.	Develop the assigned digital single complex component using SLS based 3D Printer and available material.	**CO1, CO4**
LSO 4.1. Use the available 3D printing software. *LSO 4.2.* Select printing process parameters based on the type/make of Printer and raw material *LSO 4.3.* Set printing process parameters. *LSO 4.4.* Produce a complex component using available FDM, SLA and SLS Printer. *LSO 4.5.* Perform Cost, Time, Surface finish and Strength estimations related to 3D printed components.	4.	Develop same digital single complex component using FDM, SLA and SLS based 3D Printers and compare the printed components on the basis of Cost, Time, Surface finish, Strength.	**CO1, CO2, CO3, CO4**
LSO 5.1. Use the available 3D printing software. *LSO 5.2.* Select printing process parameters based on the type/make of Printer and raw material *LSO 5.3.* Select appropriate tolerance, fit and printing process parameters. *LSO 5.4.* Produce an assembly using available SLA/SLS Printer.	5.	Print one digital assembly on SLA/SLS based 3D Printer.	**CO2/CO3/ CO4**
LSO 6.1. Use of available 3D scanner. *LSO 6.2.* Develop 3D digital model using scanning approach. *LSO 6.3.* Use the available 3D printing software. *LSO 6.4.* Produce a complex component using available SLA Printer.	6.	Scan the given real complex component and print it using FDM/SLA/SLS based 3D Printer.	**CO2, CO3, CO4**
LSO 7.1. Identify tools/devices/chemicals for post processing *LSO 7.2.* Perform post processing operations on printed component.	7.	Apply post processing techniques on the 3D printed component of experiment number 1 and/or 2 and/or 3.	**CO5**
LSO 8.1. Identify tools/devices/techniques for inspection and testing. *LSO 8.2.* Identify the defects in 3D printed components *LSO 8.3.* Apply remedial measures to bring soundness in the defective 3D printed component.	8.	Check the soundness of the 3D printed component of experiment number 1 and/or 2 and/or 3 using available devices/techniques.	**CO5**

L) **Suggested Term Work and Self Learning (2000611E):** Some sample suggested assignments, micro project and other activities are mentioned here for reference

a. **Assignments**: Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

b. **Micro Projects:**

1. Prepare a list of solid, liquid and powder form 3D printing raw materials stating their cost, colour opacity, flexibility and weight per unit volume.
2. Download 5 videos of 3D printing of different components using FDM, SLA and SLS each. Watch them and write a report to detail out the steps involved, 3D Printer used, 3D Printing software used, material used, complexity involved, printing time, post processing steps used.
3. Prepare a report on post processing steps and techniques used for 3D printed components using FDM, SLA, SLS.
4. Prepare a report to compare FDM, SLA, SLS based 3D printing process on the basis of cost, surface finish, printer setting time, printing time and post processing time and cost involved.
5. Download 5 videos of 3D printing processes **other than** FDM, SLA and SLS. Watch them and write a report to detail out the steps involved, 3D Printer used, 3D Printing software used, material used, complexity involved, printing time, post processing steps used.
6. Download 1 video related to inspection and testing of 3D printed components using different techniques like Visual inspection, Scanning Electron Microscopy (SEM), CT system, X-ray, Penetration testing, Infrared thermography, Leak or pressure testing for complex structures, Eddy current, Mechanical property inspection to measure tensile, yield, shear, fatigue, hardness, density, impact strength, Metallography (Microstructure testing). Watch them and write a report to detail out the steps involved and equipment used.

c. **Other Activities:**

1. Seminar Topics:
    - Newer 3D printing raw materials
    - Direct energy 3D printing process
    - Material jetting 3D printing process
    - Micro 3D printing process
    - Metal and Ceramic 3D printing
    - 3D printing of Jewelry
    - 3D printing of Bio implants
    - Printing of flexible plastic components

2. Visits: Visit nearby tool room/industry with 3D Printing facilities. Prepare report of visit with special comments of 3D printing technique used, material used, single component/batch production/mass production and cost of printed component.

3. Self-learning topics:
    - 3D printing of transparent, soft and flexible plastic components
    - 3D printing of metal components
    - 3D printing of ceramic components
    - 3D scanning process.
    - Chemical post processing techniques

M) **Suggested Course Evaluation Matrix:** The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

	Course Evaluation Matrix		
	Theory Assessment (TA)**	**Term Work Assessment (TWA)**	**Lab Assessment (LA)#**

COs	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	15%	15%	15%	-	-	10%	20%
CO-2	20%	20%	20%	25%	25%	25%	20%
CO-3	20%	20%	20%	25%	25%	25%	20%
CO-4	20%	20%	20%	25%	25%	25%	20%
CO-5	25%	25%	25%	25%	25%	15%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

***:** Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

****:** Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 3D Printing Materials	6	**CO1**	10	3	2	5
Unit-2.0 Solid based 3D Printing Processes	10	**CO1, CO2**	14	4	5	5
Unit-3.0 Liquid based 3D Printing Processes	10	**CO1, CO3**	14	4	5	5
Unit-4.0 Powder based 3D Printing Processes	10	**CO1, CO4**	14	4	5	5
Unit-5.0 Post Processing and Quality	12	**CO1, CO2, CO3, CO4, CO5**	18	5	5	8
Total	**48**	**-**	**70**	**20**	**22**	**28**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

SN	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Develop the assigned digital single complex component using FDM based 3D Printer and available material.	CO1, CO2	30	60	10
2.	Develop the assigned digital single complex component using SLA based 3D Printer and available material.	CO1, CO3	30	60	10
3.	Develop the assigned digital single complex component using SLS based 3D Printer and available material.	CO1, CO4	30	60	10
4.	Develop same digital single complex component using FDM, SLA	CO1, CO2,	30	60	10

SN	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
	and SLS based 3D Printers and compare the printed components on the basis of Cost, Time, Surface finish, Strength.	CO3, CO4			
5.	Print one assembly on SLA/SLS based 3D Printer.	CO2/CO3/ CO4	30	60	10
6.	Scan the given real complex component and print it using FDM/SLA/SLS based 3D Printer.	CO2, CO3, CO4	40	50	10
7.	Apply post processing techniques on the 3D printed component of experiment number 1 and/or 2 and/or 3.	CO5	40	50	10
8.	Check the soundness of the 3D printed component of experiment number 1 and/or 2 and/or 3 using available devices/techniques.	CO5	40	50	10

Legend:

PRA*: Process Assessment
PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Field Trips, Portfolio Based, Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field Information and Communications Technology (ICT)Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Session, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	High end computers	Processor Intel Core i7 with Open GL Graphics Card, RAM 32 GB, DDR3/DDR4, HDD 500 GB, Graphics Card NVIDIA OpenGL 4 GB, OS Windows 10	All
2.	Parametric Computer Aided Design software	CATIA/Solid works/NX/Creo **OR** Available with CoE	1 to 5
3.	FDM based 3D printer	Fused Deposition Modelling system with complete accessories; Build Volume-300 x 300 x 300mm or Higher; Layer Thickness-0.1 – 0.4 **OR** Available with CoE	1,4,5,6
4.	SLA based 3D printer	Printing Technology: SLA, 145 x 145 x 175mm build volume, Common layer thickness 25–100 μm, Dimensional Accuracy ± 0.5% (lower limit: ±0.10 mm), cure time of only 1-3s per layer, Material type: UV-sensitive liquid resin, Curing unit.	2,4,5,6
5.	SLS based 3D printer	Printing Technology: SLS., Build Volume: 130 x 130 x 180 mm, Recommended min. wall thickness: 0.8 mm, Powder Diameter: 60 Microns, Material Type: Nylon, TPU, Light Source: Laser Diode	3,4,5,6
6.	3D Printing Material	ABS/PLA, Resin based Photosensitive material, Polymer/metal/ceramic powder **OR** Available with CoE	1,2,3,4,5,6
7.	3D Printing software	Latest version of software like: Cura/PrusaSlicer/ideaMaker/Meshmixer/MeshLab **OR** Available with CoE	1 to 6
8.	3D Scanner and Processing software	Handheld 3D scanner, Accuracy up to 0.1 mm, Resolution up to 0.2 mm, Real time onscreen 3D model projection and processing, Wireless technology with an inbuilt touch screen and battery, Extended field of view for capturing both large and small objects, Processing Software **OR** Available with CoE	6

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
9.	Post processing equipments and tools	Deburring tools (tool handle & deburring blades), Electronic Digital Caliper, Cleaning Needles, Art knife set, Long nose pliers, Flush cutters, Wire brush, Nozzle cleaning kit, Tube cutter, Print removal spatula, Needle file, Cutting mat, Glue stick, Wire stripper, Chemicals, Etching agents etc.	7
10.	Inspection and Testing devices	• Visual inspection, Devices related to: • Scanning electron microscopy (SEM), CT system, X-ray, • Penetration testing, • Infrared thermography, • Leak or pressure testing for complex structures, • Eddy current, • Mechanical property inspection to measure tensile, yield, shear, fatigue, hardness, density, impact strenght • Metallography (Microstructure testing)	8

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing	Lan Gibson, David W. Rosen, Brent Stucker	Springer, 2010 ISBN: 9781493921133
2.	Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing	Andreas Gebhardt,	Hanser Publisher, 2011 ISBN: 156990507X, 9781569905074
3.	3D Printing and Design	Sabrie Soloman	Khanna Publishing House, Delhi ISBN: 9789386173768
4.	3D Printing and Rapid Prototyping- Principles and Applications	C.K. Chua, Kah Fai Leong	World Scientific, 2017 ISBN: 9789813146754
5.	Getting Started with 3D Printing: A Hands-on Guide to the Hardware, Software, and Services Behind the New Manufacturing Revolution	Liza Wallach Kloski, Nick Kloski	Make Community, LLC; 2nd edition, 2021 ISBN: 9781680450200
6.	Laser-Induced Materials and Processes for Rapid Prototyping	L. Lu, J. Fuh, Y.S. Wong	Kulwer Academic Press, 2001 ISBN: 9781461514695
7.	3D Printing: A Practical Guide	Clay Martin	Larsen and Keller Education 2023 ISBN 9781641728323
8.	Fundamentals of 3D Printing	Elizah Brooks	Clanrye International 2023 ISBN 9781647290943
9.	Principles of 3D Printing	Brady Hunter	NY Research Press 2023 ISBN 9781632389549

(b) Online Educational Resources:

1. https://onlinecourses.nptel.ac.in/noc21_me115/preview
2. https://archive.nptel.ac.in/courses/112/104/112104265/
3. https://bigrep.com/post-processing/
4. https://www.mdpi.com/2227-7080/9/3/61
5. https://all3dp.com/2/best-3d-printing-books/
6. https://www.youtube.com/watch?v=TQY2lF-sFaI
7. https://www.youtube.com/watch?v=Oz0PoS5LPxg
8. https://www.youtube.com/watch?v=6ejjh0GdyDc

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

(c) Others:

1. 3D Printing Projects DK Children; Illustrated edition, 2017
2. The 3D Printing Handbook: Technologies, design and applications Ben Redwood, Filemon Schöffer, Brian Garret, 3D Hubs; 1st edition, 2017
3. https://www.improprecision.com/inspection-method-for-3d-printed-parts/
4. 3D Printer Users' Guide
5. 3D Printer Material Handbook
6. Lab Manuals

S) Course Curriculum Development Team (NITTTR, Bhopal)

- Dr. Sharad Pradhan (Coordinator)
- Dr. A. K. Sarathe (Co-coordinator)

******

A) Course Code : **2000605F/2000608F/2000611F**

B) Course Title : Industrial Automation (Advance)

C) Pre- requisite Course(s) : Industrial automation (Basic)

D) Rationale :

This course on Advanced industrial automation offers students a hands-on approach to implement industrial control using modern controllers like Programmable Logic Controller (PLC), Distributed Control System (DCS)Supervisory Control and Data Acquisition (SCADA). Students will learn to identify and connect field inputs and outputs; communicate with, and program microprocessor-based controllers. Students will also connect, communicate with, and develop displays for computer-based operator interfaces. Process manufacturers typically employ Distributed Control System (DCS) Supervisory Control and Data Acquisition (SCADA) technologies to monitor and control the operations in their facilities. DCS and SCADA systems are now doing much more than simply monitoring and controlling. The course will enable the students to use of basic instructions and addressing, advanced PLC instructions in Ladder Logic and to identify and troubleshoot the faults in PLC system and do PLC maintenance. This course also introduces the students to industrial automation communications, PLC maintenance and troubleshooting also to become a successful automation engineer.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

CO-1. Apply the principles of communication for industrial automation.

CO-2. Test the output of the PLC ladder logic programs for the given application

CO-3. Maintain PLC systems

CO-4. Use SCADA for supervisory control and for acquiring data from the field.

CO-5. Develop simple automation systems

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	**Programme Outcomes (POs)**							**Programme Specific Outcomes* (PSOs)**	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Developmen tof Solutions	**PO-4** Engineeri ngTools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Managem ent	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	3	2	2	2	2	-	2		
CO-2	3	3	3	3	-	-	2		
CO-3	3	3	3	3	2	2	2		
CO-4	3	2	2	2	2	2	2		
CO-5	3	2	2	3	2	2	2		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

* PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Board of Study	Course Code	Course Title	Scheme of Study (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
	2000605F/ 2000608F/ 2000611F	Industrial Automation (Advance)	03	-	04	02	09	05

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances/ problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, Online educational resources etc.

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Assessment Scheme:

Board of Study	Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
	2000605F/2000608F/2000611F	Industrial Automation (Advance)	30	70	20	30	20	30	200

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self -learning, any other student activities etc.

Note:

- Separate passing is must for progressive and end semester assessment for both theory and practical.
- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self -learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

I) **Course Curriculum Detailing:** This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction

(LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.1a Describe how does a PLC communicate? TSO.1b Differentiate between parallel and series communication TSO.1c Describe the data transfer mechanism for the given communication protocols. TSO.1d Describe the given communication protocol used in PLC communication. TSO.1e Summarize PLC to PLC communication procedure TSO.1f Describe the common procedureto interface the PLC with other given hardware.	**Unit-1.0 Industrial automation communication and Interfacing** 1.1 Analog and Digital Communications on Plant Floors 1.2 Introduction to Industrial Networking 1.3 RS232-422-485 standards for data communication 1.4 Industrial Ethernet 1.5 Concept of Fieldbus 1.6 MODBUS protocol 1.7 Highway Addressable Remote Transducer (HART) Protocol 1.8 Interfacing of Programmable Logic Controller with other hardware	**CO-1**
TSO.2a Specify the proper I/O addressing format of the given PLC. TSO.2b Explain the use of different relay type instructions for the given operation. TSO.2c Describe how a program is executed with the help of Program Scan cycle TSO.2d Develop ladder logic program using arithmetic functions to perform the given operation. TSO.2e Develop ladder logic programs using logical and comparison instructions to perform the given operation TSO.2f Develop ladder logic programs using on delay, off delay and reset/retentive timer in a given PLC to create a delay in operation. TSO.2g Develop ladder logic programs using Up, Down and UP-down counter in a given PLC to count the number of products	**Unit-2.0 PLC Programming** 2.1 PLC I/O addressing in ladder logic 2.2 PLC programming instructions using ladder logic and relay type instructions 2.3 Program Scan cycle 2.4 PLC arithmetic functions - Addition, subtraction, multiplication, division instructions, increment decrement, trigonometric 2.5 PLC logical functions - AND, OR, XOR, NOT functions, PLC compare and convert functions. 2.6 Programming Timer –Addressing a timer block, status bits, On delay, Off Delay and reset/retentive timer 2.7 Programming Counter- Addressing a counter block, status bits, Up and Down counter, up-down counter, counter examples, register basics 2.8 Develop ladder logic for various simple applications	**CO-2**
TSO.3a Describe Requirements for PLC enclosure. TSO.3b Describe Proper grounding techniques. TSO.3c Describe noise reduction Techniques. TSO.3d Explain preventive maintenance procedure associated with PLC	**Unit-3.0 Installation and maintenance of PLC systems** 3.1 PLC enclosure, grounding requirements, noise generating inductive devices, leaky inputs and outputs, techniques to reduce electrical noise and leakage. 3.2 Introduction to PLC Trouble shooting and maintenance, trouble shooting of hardware and software. 3.3 Diagnostic LED Indicators in PLCs 3.4 Common problems	**CO-3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
system to reduce environmental impact TSO.3e Identify faults in the given PLC system TSO.3f Explain the procedure for Troubleshooting PLC system TSO.3g Prepare preventive maintenance plan for the PLC system TSO.3h Use safety equipment's. TSO.3i Follow safe practices	• Internal problems – Check for PLC Power Supply, Emergency Push Button, Power Supply Failure, Battery Failure, Electrical Noise Interference, Verify the PLC Program with the Master Program, Corrupted PLC Memory • External problems - Power failure, faulty grounding and electrical noise interference (RFI or EMI), Status of the Output Modules and their associated Circuitry, Status of the Input Modules and their associated Circuitry, Field Input and Output Devices, Communication Issues. • Environmental Conditions. Check for humidity, temperature, vibration, and noise-level limits specified by its manufacturer 3.5 Troubleshooting of Specific Components of the PLC System • Power Supply Troubleshooting • I/O Modules Troubleshooting • Troubleshooting PLC Program Errors • Troubleshooting the Working Environment of a PLC • Replacement of CPU 3.6 PLC trouble shooting flowchart 3.7 PLC maintenance – PLC maintenance checklist, preventive maintenance procedure, maintenance plan for the PLC system. 3.8 Safety procedure and safety equipment's.	
TSO.4.a Describe the function of given element of a SCADA system. TSO.4.b Interface the given PLC with SCADA system using the given Open Platform Communications (OPC). TSO.4.c Describe the steps to develop a simple SCADA screen for the given industrial application. TSO.4.d Describe the procedure to maintain the SCADA based PLC system for the given application.	**Unit-4.0 SCADA and DCS** 4.1 Introduction, need, benefits and typical applications of SCADA and DCS 4.2 SCADA Architecture - Remote Terminal Units (RTUs), Master Terminal Units, Various SCADA editors, Communication protocols for SCADA 4.3 Comparison of SCADA with DCS 4.4 Interfacing SCADA system with PLC- Typical connection diagram, Object Linking and Embedding for Process Control (OPC) architecture 4.5 Creating SCADA Screen HMI for simple object, Steps for linking SCADA object (defining Tags and items, creating trends etc.,) with PLC ladder program using OPC, configuring simple applications using SCADA: Traffic light control, water distribution, pipeline control, Power generation, transmission and distribution etc. 4.6 Procedure to maintain the SCADA based PLC system.	**CO-3**
TSO.5a Identify different components used for automation in the given system TSO.5b Select automation components for a given situation TSO.5c In the given manufacturing or service industry Identify the areas where automation is possible. TSO.5d Prepare plan for sustainable automation as per the requirement.	**Unit-5.0 Applications of Industrial Automation** 5.1 **Manufacturing-** Industrial Robots- welding robots, pick and place robots, Cabot's, Machine monitoring system, supply chain, Automated assembly system, Flexible Automation and programmable Automation. 5.2 **Health Care-** microscopic robots for medical diagnosis, automated medication dispensing devices, AESOP, ZEUS, RP_7(remote presence 7th generation), DaVinci 5.3 **Defense- guided rockets and missiles,** counter measures, UAV drones, launcher, radar antenna, engagement control system	**CO-5**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	5.4 **Automobile –B**reak monitoring system, Vehicle tracking system, Rear-view alarm to detect obstacles behind, Four-wheel drive, Traction control system, Dynamic steering response, Anti-lock braking system (ABS) Adaptive cruise control, Adaptive headlamps, Intelligent Parking Assist System, Driverless/Autonomous Cars 5.5 **Agriculture-** harvesters, irrigation systems, plowing machines, self-driving tractors, grain yield sensor 5.6 **Mining-** Mine planning system, mine picture compilation, mine control system, seismic imagining, laser imaging, Rig control system, automated drilling, automated exploration, automated truck	

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical (2000608F):

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSOs 1.1 Data communication from PLC to PC and vice versa	1.	Transfer the control data from PLC to PC and vice versa	**CO1**
LSOs 1.2 Establish Communication channels between PLC s.	2.	Transfer the control data from PLC to PLC	**CO1**
LSOs 1.3 Transfer data from sensors to PLC and from PLC to PC.	3.	Transfer the sensor data from sensor to PLC to PLC and PC	**CO1**
LSOs 1.4 Interface the given PLC with a PC or a Laptop	4.	Interface the given PLC with a PC or a Laptop	**CO1**
LSOs 2.1 Identify Different parts and front panel indicators of a PLC	5.	Identify the various parts and front panel status indicators of the given PLC.	**CO2**
LSOs 2.2 Develop Ladder logic program for different arithmetic operations	6.	Develop/Execute ladder logic program for different arithmetic operations such as Addition, subtraction, multiplication, division increment, decrement, trigonometric in a given PLC	**CO2**
LSOs 2.3 Develop Ladder logic program for different logical operations	7.	Develop/Execute ladder logic program for logical operations such as AND, OR, NOT, NAND, NOR, X-OR, X-NOR gate along with truth table	**CO2**
LSOs 2.4 Program Latch and Unlatch circuit in a PLC for motor operation	8.	Program the given PLC to start run and stop the given motor using latch circuit	**CO2**
LSOs 2.5 Create delay in operation using on delay, off delay and retentive timer function in a given PLC.	9.	Test the functionality of on delay, off delay and retentive timer for its correct operation in a given PLC.	**CO2**
LSOs 2.6 Count the number of objects/events using Up counter, Down counter and UP/Down counter in a PLC	10.	Test the functionality of Up, Down and Up-down counter for its correct operation in a given PLC.	**CO2**
LSOs 2.7 Program PLC using ladder logic to control a LED/Lamp	11.	Develop/Execute a ladder logic program to put LED/lamp in the blinking mode	**CO2**
LSOs 2.8 Program PLC using ladder logic to control a simple traffic light system	12.	Develop/Execute a ladder logic program to control a simple traffic light control system using PLC	**CO2**

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSOs 3.1 Use hygrometer to measure the humidity inside the panel *LSOs 3.2* Use thermometer to measure ambient temperature inside the panel *LSOs 3.3* Use tester to determine the voltage fluctuation at the power supply terminals is within specifications *LSOs 3.4* Test the ground connections of the given PLC. *LSOs 3.5* A given PLC is not working as per the logic instructions investigate the PLC to identify the cause of failure to show the desired output *LSOs 3.6* Investigate the cause of Noise in the given PLC *LSOs 3.7* PLC goes on blackout out by losing its operating power. Troubleshoot the cause of failure. *LSOs 3.8* Troubleshoot the corrupted PLC memory. *LSOs 3.9* Replace CPU and power supply fuses in a given PLC system.	13.	Troubleshooting of PLC system	**CO3**
LSOs 4.1 Download any open source SCADA software and install the same. *LSOs 4.2* Interpret the available components in symbol factory of SCADA software *LSOs 4.3* Create simple SCADA HMI applications and apply dynamic properties. (Select any Three from the given list) i. Turn on and off a tube light using a Switch ii. Apply filling and object size properties to a rectangle, square and round object iii. Move the object, fill the object using slider and meter reading. iv. Apply orientation property to a fan and control its direction using a slider. v. Move a square object horizontally first, then vertically and again horizontally by applying visibility property. *LSOs 4.4* Create historical and real time trends for the given automation	14.	Develop simple SCADA HMI applications using any one open source SCADA software and apply dynamic properties	**CO4**
LSOs 5.1 Develop a smart irrigation device to detect the change in moisture level in the soil and controls the flow of water accordingly with a DC pump. *LSOs 5.2* Build an electronic device that can remotely control home appliances with your Bluetooth-enabled smartphone and a special Android application	15.	Develop simple automation systems for the given requirement (Select any Three from the given list)	**CO5**

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSOs 5.3 Develop a PLC program to control the robot in such a way that the robot can automatically pick and place components and works in sync with the conveyor belt system. *LSOs 5.4* Develop a Automation system to Open and close the door in the shop *LSOs 5.5* Develop a line following robot with RFID sensor for supplying materials and automating workflow. *LSOs 5.6* Develop smart street light controlling mechanism which will Switch on/off the lights automatically depending on the intensity of the sunlight at that particular time of the day. *LSOs 5.7* Develop smart automated railway crossing system to detect train arrival and departure and send appropriate signals to the microcontroller.			

L) Suggested Term Work and Self Learning (2000611F): Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. Assignments: Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

i. State three advantages of using programmed PLC timer over mechanical timing relay.
ii. It is required to have a pilot light glow, meeting all of the circuit requirements given below:
   - All four circuit pressure Switches must be closed.
   - At least two out of three circuit limit Switches must be closed.
   - The reset Switch must not be closed.
iii. Using AND, OR, and NOT gates, design a logic circuit that will solve this hypothetical problem
iv. Prepare a comparison chart of different types of PLC
v. Prepare a maintenance plan for a given PLC system.

b. Micro Projects:

1. Troubleshoot the faulty equipment/kit available in automation laboratory
2. Select one industry and analyze the process and propose the automation strategies' that can be used for automation.
3. Develop a working model of a given application using given actuators and valves.
4. Develop a smart irrigation device to detect the change in moisture level in the soil and controls the flow of water accordingly with a DC pump.
5. Build an electronic device that can remotely control home appliances with your Bluetooth-enabled smartphone and a special Android application
6. Develop a PLC program to control the robot in such a way that the robot can automatically pick and place components and works in sync with the conveyor belt system.

c. Other Activities:

1. Seminar Topics- PLC instructions, Timers and Counters used in a given PLC

2. Seminar Topics- Industrial Applications of PLC and SCADA, AGV, Application of automation in different area, trouble shooting of different types of PLC
3. Visits – Visit any industry with full or semi automation and prepare a report on industrial automation used by the industry in the given section, components used, power requirement, output achieved and maintenance activities required.
4. Surveys- Carry out a market/internet survey of PLC and prepare the comparative technical specifications of any one type of PLC (Micro or Mini) of different manufacturer.
5. Product Development- Develop a prototype automatic railway crossing system
a. Software Development- Download any open source software for PLC and install on your laptop/PC and carry out basic PLC programming
6. Also download any open source software for SCADA and install on your laptop/PC and carry out basic SCADA HMI programming
7. Surveys – Carry out a internet based survey to compare SCADA and DCS

d. Self-learning topics:

- Basic concepts of working of robot
- Automated material handling.
- Instrumentation systems for inspection and testing for quality of the product
- Use of robots in different applications
- Intelligent Transportation Systems
- Communication standards and protocols used in PLC
- Use of PLC for different industrial applications
- Use of SCADA for different industrial applications
- Interfacing of PLC

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self-Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	10%	20%	20%	--	33%	10%	20%
CO-2	15%	25%	20%	--	33%	15%	20%
CO-3	15%	20%	20%	--	34%	15%	20%
CO-4	30%	20%	20%	50%	--	30%	20%
CO-5	30%	15%	20%	50%	--	30%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:
*: Other Activities include self-learning, seminar, visits, surveys, product development, software development etc.
**: Mentioned under point- (N)
#: Mentioned under point- (O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-.1.0 Industrial automation Communication and Interfacing	9	**CO1**	14	5	4	5
Unit-.2.0 PLC Programming	12	**CO2**	17	5	6	6
Unit-.3.0 Installation and maintenance of PLC systems	10	**CO3**	14	4	5	5
Unit-.4.0 SCADA and DCS	9	**CO4**	14	4	5	5
Unit-.5.0 Applications of Industrial Automation	8	**CO5**	11	2	4	5
Total Marks	**48**		**70**	**20**	**24**	**26**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Transfer the control data from PLC to PC and vice versa	CO1	50	40	10
2.	Transfer the control data from PLC to PLC	CO1	50	40	10
3.	Transfer the sensor data from sensor to PLC to PLC and PC	CO1	50	40	10
4.	Interface the given PLC with a PC or a Laptop	CO1	50	40	10
5.	Identify Different parts and front panel indicators of a PLC	CO2	50	40	10
6.	Develop Ladder logic program for different arithmetic operations	CO2	50	40	10
7.	Develop Ladder logic program for different logical operations	CO2	50	40	10
8.	Program Latch and Unlatch circuit in a PLC for motor operation	CO2	50	40	10
9.	Create delay in operation using on delay, off delay and retentive timer function in a given PLC	CO2	50	40	10
10.	Count the number of objects/events using Up counter, Down counter and UP/Down counter in a PLC	CO2	50	40	10
11.	Program PLC using ladder logic to control a LED/Lamp	CO2	50	40	10
12.	Program PLC using ladder logic to control a simple traffic light system	CO2	50	40	10

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
13.	Use hygrometer to measure the humidity inside the panel	CO3	50	40	10
14.	Use thermometer to measure ambient temperature inside the panel	CO3	50	40	10
15.	Use tester to determine the voltage fluctuation at the power supply terminals is within specifications	CO3	50	40	10
16.	A given PLC is not working as per the logic instructions investigate the PLC to identify the cause of failure to show the desired output	CO3	50	40	10
17.	Investigate the cause of Noise in the given PLC	CO3	50	40	10
18.	PLC goes on blackout out by losing its operating power. Troubleshoot the cause of failure.	CO3	50	40	10
19.	Troubleshoot the corrupted PLC memory.	CO3	50	40	10
20.	Replace CPU and power supply fuses in a given PLC system	CO3	50	40	10
21.	Download any open source SCADA software and install the same.	CO4	50	40	10
22.	Interpret the available components in symbol factory in SCADA software	CO4	50	40	10
23.	Create simple SCADA HMI applications and apply dynamic properties **(Any Three).** i. Turn on and off a tube light using a Switch ii. Apply filling and object size properties to a rectangle, square and round object iii. Move the object, fill the object using slider and meter reading. iv. Apply orientation property to a fan and control its direction using a slider. v. Move a square object horizontally first, then vertically and again horizontally by applying visibility property.	CO4	50	40	10
24.	Create historical and real time trends for the given automation	CO4	50	40	10
24	**Select any three of the following: -** i. Develop a smart irrigation device to detect the change in moisture level in the soil and controls the flow of water accordingly with a DC pump. ii. Build an electronic device that can remotely control home appliances with your Bluetooth-enabled smartphone and a special Android application iii. Develop a PLC program to control the robot in such a way that the robot can automatically pick and place components and works in sync with the conveyor belt system. iv. Develop a Automation system to Open and close the door in the shop v. Develop a line following robot with RFID sensor for supplying materials and automating workflow. vi. Develop smart street light controlling mechanism which will Switch on/off the lights automatically depending on	CO5	60	30	10

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
	the intensity of the sunlight at that particular time of the day. vii. Develop smart automated railway crossing system to detect train arrival and departure and send appropriate signals to the microcontroller.				

Legend:

PRA*: Process Assessment
PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	SCADA software (reputed make like Allen Bradley, Siemens etc.,)	Ready-to-use symbol library, React and respond in real-time, Real time monitoring, Friendly, manageable, secure, extensible, Easy-to-use, easy to implement, Easy configuration, simplified maintenance, Communication with PLC, easy and flexible alarm definition, data collection and analysis for new and existing systems, easy-to-use for report generation, open access to historical data, different packages available with input/output structure. Open source software SCADA software: like Ellipse/FTVSE/Wonderware/ open SCADA can also be used	14
2.	Universal PLC Training System with HMI (Of reputed make such as Allen bradely, Siemens, etc.,) Compatible with SCADA software	Human Machine Interface (HMI) display, PLC with 16 digital inputs, 16 digital outputs with RS232 communication facility. Open platform to explore wide PLC and HMI applications. Industrial look & feel. Toggle Switches, push to ON Switch, proximity sensor, visual indicator, audio indicator, and DC motor. Experiments configurable through patch board.Powerful instruction sets. Several sample ladder and HMI programs. PC based ladder and HMI programming. Extremely easy and student friendly software to develop differentprograms. Easy downloading of programs. Practice troubleshooting skills. Compact tabletop ergonomic design. Robust construction. PLC gateway for cloud connectivity. Open source software like Ladder logic simulator, Pico soft Simulator, Logixpro simulator, Simple EDA tools can also be used	1 to 12
3.	Safety gears	Gloves, Safety goggles, Ear protection, Dust masks and respirators.	13
4.	Power tools	Power drills, Orbital sanders, Circular saws, Impact wrenches.	13
5.	Hand tools	Screwdrivers, Hammers, Hand saws, Hex Key Allen Wrench Set Inch and Metric, relay puller, Multi-Tool Wire Stripper/Crimper/Cutter	13

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
6.	Electrical tools	Wire and cable strippers, Multimeters- Volts, Ohms, and Amps, Crimpers- Side Cutter Crimping, Wire Crimp Connector Kit, Digital Multimeter Clamp Meter with Amp, Volt, and Ohm, Non-Contact Voltage Tester	13
7.	Spare parts	PLC Programming Cables, SD Card Reader Compact flash, Wire Nut Set, Fuses- Class J 30, 35, 60, and 100 -amp fuses, Class CC 2, 3, 5, 10 , 15, 20, and 30 -amp fuses, 5mm x 20mm 0.032 (for 4 -20mA circuits), 0.5, 1, 2, 5, 10, and 15 amps, Cube Relays, Resistor Kit, batteries, LED Indicators PLC Processor (CPU), Input/ output module	13
8.	Thermo-hygrometer	Measuring range Temp.: -30 ... 60°C / -22 ... 140°F Measuring range rel. Humidity: 0 ... 100% rh, Measurement protocol as PDF, Data export possible as CSV, Readable without software, data sets of measured values can be stored.	13
9.	Digital Hygrometer	maximum humidity measurement- 100%RH, temperature measurement resolution -0.1egree centigrade, humidity measurement resolution -0.1%RH, minimum operating temperature - -10 to -20-degree centigrade, Maximum operating temperature +45 to +50 degree centigrade	13

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Introduction to Programmable Logic Controllers	Dunning, G.	Thomson /Delmar learning, New Delhi, 2005, ISBN 13: 9781401884260
2.	Programmable Logic Controllers	Petruzella, F.D.	McGraw Hill India, New Delhi, 2010, ISBN: 9780071067386
3.	Programmable Logic Controllers	Hackworth, John; Hackworth, Federic	PHI Learning, New Delhi, 2003, ISBN: 9780130607188
4.	Industrial automation and Process control	Stenerson Jon	PHI Learning, New Delhi, 2003, ISBN: 9780130618900
5.	Programmable Logic Controller	Jadhav, V. R.	Khanna publishers, New Delhi, 2017, ISBN: 9788174092281
6.	Programmable Logic Controllers and Industrial Automation - An introduction,	Mitra, Madhuchandra; Sengupta, Samarjit,	Penram International Publication, 2015, ISBN: 9788187972174
7.	Control System	Nagrath & Gopal	New Age International Pvt Ltd, ISBN: 9789386070111, 9789386070111
8.	Linear Control Systems with MATLAB Applications, Publisher:	Manke, B. S.	Khanna Publishers, ISBN: 9788174093103, 9788174093103
9.	Supervisory Control and Data Acquisition	Boyar, S. A.	ISA Publication, USA, ISBN: 978-1936007097
10.	Practical SCADA for industry,	Bailey David; Wright Edwin	Newnes (an imprint of Elsevier), UK 2003, ISBN:0750658053
11	Industrial Automation: Systems and Engineering	Geoffrey Williamson	States Academic Press , 2022 ISBN 9781649649270
12	Industrial Automation Technologies	Jane Taylor	States Academic Press 2023 ISBN 9781649649255
13	Introduction to Industrial Automation	Kian Pearson	Willford Press 2023, ISBN 9781682860864

(b) Online Educational Resources:

1. Software: - www.fossee.com

2. Software: - www.logixpro.com
3. Software: - www.plctutor.com
4. Software; - www.ellipse.com
5. PLC lecture: - https://www.youtube.com/watch?v=pPiXEfBO2qo
6. PLC tutorial: http://users.isr.ist.utl.pt/~jag/aulas/apil3/docs/API_I_C3_3_ST.pdf
7. https://www.youtube.com/watch?v=277wwYWolpw-PLC system troubleshooting and repair. Industrial control panel. PLC system repair.
8. https://www.youtube.com/watch?v=5Jmtvrch5Jg
9. https://www.youtube.com/watch?v=peyV9bwEaLY
10. https://www.youtube.com/watch?v=QdJhRmtKpxk&list=RDCMUCke36Liq-w5fboMHkq1APZw&index=3
11. https://www.youtube.com/watch?v=ygrrRwaJz3M

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested OER, before use by the students.

(c) Others:

1. Learning Packages
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

S) Course Curriculum Development Team (NITTTR, Bhopal)

- Dr. Vandana Somkuwar (Coordinator)
- Dr. C.S.Rajeshwari (Co-coordinator)

*****

A) Course Code : **2000605G/2000608G/2000611G**

B) Course Title : Electric Vehicle (Advanced)

C) Prerequisite Course(s) : Electric Vehicle (Basics)

D) Rationale :

The automobile manufacturing sector in India is rapidly switching over to electric vehicles used for the public as well as private transport. The Govt. of India has launched the FAME-II Scheme (Faster Adoption and Manufacturing of Hybrid & Plug-in Electric Vehicles) to encourage the progressive induction of reliable, affordable and efficient electric and hybrid vehicles and to create demand for Electric Vehicles in the country. The technology is being evolved to enhance the vehicle's efficiency and running mileage by controlling the manufacturing, maintenance and recurring costs of such vehicles. Due to the rapid increase in EV demand, industries will also require skilled manpower in this area. This advanced course on electric vehicles is included as an open elective for all the diploma programmes to provide a sound knowledge of EVs to engineering diploma students and develop skills related to testing and maintenance of various electrical, electronic and mechanical systems in EVs.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the learners' accomplishment of the following course outcomes. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the student will be able to-

CO-1 Compute various parameters affecting Vehicle movement.

CO-2 Test the operation of the different elements of the Automobile System.

CO-3 Test the battery and motor used for Power Transmission in EVs.

CO-4 Test electronic control unit system of EVs.

CO-5 Interpret the impact of Grid to Vehicle (G2V) and Vehicle to Grid (V2G) during the charging cycle.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	3	-	1	2	-	-	1		
CO-2	3	2	2	3	1	-	-		
CO-3	2	2	2	3	3	1	3		
CO-4	2	3	-	2	2	-	2		
CO-5	3	2	-	2	3	1	2		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

* PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Board of Study	Course Code	Course Title	Scheme of Study (Hours/Week)						
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
	2000605G/ 2000608G/ 2000611G	Electric Vehicle (Advanced)	03	-	04	02	09	05

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Assessment Scheme:

Board of Study	Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
	2000605 G/20006 08G/200 0611G	Electric Vehicle (Advanced)	30	70	20	30	20	30	200

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- Separate passing is must for progressive and end semester assessment for both theory and practical.
- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

I) **Course Curriculum Detailing**: This course curriculum detailing depicts learning outcomes at the course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to the attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020-related reforms like

Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain the vehicle movement process TSO 1b. Derive various equations for the movement of Vehicles TSO 1c. Compute different resistances affecting Vehicle movement. TSO 1d. Explain the dynamics of the given type of EV system.	**Unit-1.0 Vehicle Dynamics** 1.1 Vehicle Movement 1.2 Rolling Resistance: Equation, Coefficient, factor affecting rolling resistance, typical values of rolling resistance 1.3 Grading resistance 1.4 Road resistance 1.5 Acceleration resistance 1.6 Total driving resistance 1.7 Aerodynamic drag: Equation, typical values of the drag coefficient. 1.8 Vehicle dynamics • Hybrid and Electric Vehicles • DC Motor Dynamics and Control • AC Motor Dynamics and Control	**CO1**
TSO 2 a. Identify the given elements of Automobile Systems. TSO 2 b. Describe the functions of the given elements of Automobile Systems. TSO 2 c. Explain the dynamic characteristics of the Disc Braking System for the given braking steps. TSO 2 d. Describe the Procedure for testing the given AC/DC motors. TSO 2 e. Describe the Procedure of Installation and Testing of the given EV Charging Stations. TSO 2 f. Describe the Procedure for Commissioning EV Charging Stations. TSO 2 g. Explain the functions of the EV Control Unit.	**Unit-2.0 Elements of Automobile** 2.1 Suspension and Damping systems 2.2 Brake system: Half-step braking, Full step Braking 2.3 Transaxle 2.4 Elements of Noise Vibration and Harshness Control 2.5 Body balancing 2.6 Tyre Technology 2.7 AC/DC motor 2.8 Air-conditioning and Heating System 2.9 Lighting System 2.10 Automotive wiring system 2.11 Earthing and Insulation 2.12 Charging stations – Installation and Commissioning 2.13 Vehicle control unit	**CO2**
TSO 3a. Compare different power transmission systems in EVs. TSO 3b. List the main Components of the EV Power Train. TSO 3c. Explain the functions of the given EV Power Train component. TSO 3d. Describe the testing procedure of the given EV Power Train component. TSO 3e. Explain the regenerative braking operation in the given EV motor. TSO 3f. Describe the speed control mechanism of the given motor. TSO 3g. Explain various parameters of the given battery. TSO 3h. Select the suitable battery for the given EV application. TSO 3i. Describe the assembling and dismantling procedure of the given battery.	**Unit-3.0 EV Power Transmission System** **3.1 Transmission System**: Single and Multi-transmission system **3.2 EV Power Train** **3.3 EV Power Train Components**: Battery Pack, DC-AC Converter, Electric Motor, On-Board Charger. **3.4 Battery Parameters**: Voltage, Current, Charging rate, efficiency, energy density, power density, State of Charge (SoC), Depth of Discharge (DoD), State of Health (SoH), Operating Temperature, specific energy, specific power, life cycle and cost. **3.5** Battery Assembly and Dismantling. **3.6** Gear and Differential Assembly **3.7** Safe disposal of used battery	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 3j. Describe the Mechanism of Gear and Differential Assembly.		
TSO 4a. Describe the Vehicle Control Unit (VCU). TSO 4b. Describe the functions of the given component of the Electronic Control Unit. TSO 4c. Describe the connections of the given control unit with the EV sub-system. TSO 4d. Explain the Interaction of Controller Area Network Communication with VCU. TSO 4e. Describe the Troubleshooting and Assessment procedure of VCU.	**Unit- 4.0 Vehicle Control Unit (VCU)** 4.1 **Electronic Control Unit**: Battery Management System, DC-DC Converter, Thermal Management System and Body Control Module. 4.2 Predefined functions 4.3 Connections with EV subsystem 4.4 Controller Area Network (CAN) communication 4.5 Interaction of CAN Communication with VCU. 4.6 Troubleshooting and Assessment 4.7 Dynamometers: Introduction 4.8 Environmental Chambers	**CO4**
TSO 5a. Explain the Classification of Charging Technologies. TSO 5b. Explain the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid. TSO 5c. Describe the testing procedure of the given Bi-directional charging systems. TSO 5d. Explain the Energy Management Strategies in the EV. TSO 5e. Explain the Wireless Power Transfer (WPT) technique for EV Charging.	**Unit- 5.0 EV Charging Technologies** 5.1 Charging Technology: Classification 5.2 Grid-to-Vehicle (G2V) 5.3 Vehicle to Grid (V2G) or Vehicle to Buildings (V2B) or Vehicle to Home(V2H). 5.4 Bi-directional EV Charging Systems. 5.5 Energy Management Strategies. 5.6 Wireless Power Transfer (WPT) technique for EV Charging.	**CO5**

Note: One major TSO may require more than one theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical (2000608G):

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 2.1 Test the operation of the Control Disc Braking system and control the regenerative braking system using a test rig. LSO 2.2 Test the performance (Speed v/s Braking Torque) of the Disc Braking System in Half step and Full step braking modes.	1.	• Testing of Control Disc Braking system and Control Regenerative Braking system.	**CO2**
LSO 2.3 Test the performance of different types of propulsion motors.	2.	• Testing of Motors	
LSO 2.4 Test the continuity of the automotive wiring system in the EV	3.	• Testing of the automotive wiring system.	
LSO 3.1 Test the performance of a new set of batteries and aged batteries. LSO 3.2 Compare the performance of the battery and find the Fuel Gauge after discharging the battery. a. 0% - 100% b. 30% - 100% c. 50% - 100% LSO 3.3 Evaluate the following parameters of the given EV battery. a. Specific power b. Specific energy	4.	• Testing of Batteries used in EVs	**CO2, CO3**

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
c. Life span and d. Cost parameters LSO 3.4 Evaluate the State of Health (SoH) of the given EV Battery after several charge/discharge cycles.			
LSO 3.5 Test the dynamic performance of the given motor; a) Speed and torque spectrum. b) Speed and torque oscillation c) Friction torque friction spectrum. LSO 3.6 Test the following speed-controlled performance characteristics of the given motor; a. Motor voltage over time b. Motor current over time. c. Speed and torque over time. d. Torque over speed. e. Current over speed. f. Electrical input power and the mechanical input power over speed	5.	• Speed control of Electrical Motors	
LSO 4.1 Connect the components of the EC Units with EV subsystems. LSO 4.2 Troubleshoot basic faults in the electronic control unit of EV.	6.	• Connection of Electronic Control Unit components • Troubleshooting of electronic control unit	**CO4**
LSO 5.1 Evaluate the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid.	7.	• Impacts of G2V and V2G	**CO 5**
LSO 5.2 Prepare a layout of a charging station	8.	• Demonstration of Charging stations	

L) Suggested Term Work and Self-Learning (2000611G): Some sample suggested assignments, micro projects and other activities are mentioned here for reference.

a. Assignments: Questions/ Problems/ Numerical/ Exercises to be provided by the course teacher in line with the targeted COs.

b. Micro Projects:

1. Design and build a physical model of an EV motor and powertrain components from scratch.
2. Build and simulate communication systems of EVs using some software tools.
3. Prepare a report on “the way carbon credit works and companies utilize it to reduce their emission values”.
4. Develop an EV prototype power train using locally procured hardware components.

c. Other Activities:

1. **Seminar Topics**:
   - Safe disposal process of Used Batteries.
   - Charging Technologies used for charging the EV.
   - EV power transmission systems.
2. **Surveys** – Visit an electric vehicle manufacturing plant and prepare report on HVAC system used in EV.

3. **Self-learning topics:**
   - Impact of fleet charging of EVs on Power Systems.
   - Energy Management in EV.
   - Fuel Cell powered bus.
   - EV Battery disposal and recycling.
   - Mobility and connectors.

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use the appropriate assessment strategy and its weightage, in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of the student in each of these designed activities is to be used to calculate **CO attainment.**

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self-Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	20%	15%	20%	--	--	--	--
CO-2	20%	20%	20%	--	--	35%	25%
CO-3	20%	30%	20%	70%	40%	40%	25%
CO-4	20%	25%	20%	30%	20%	10%	25%
CO-5	20%	10%	20%	--	40%	15%	25%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:
***:** Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.
****:** Mentioned under point- (N)
#: Mentioned under point- (O)

Note:
- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of the cognitive domain of the full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Vehicle Dynamics	8	**CO1**	12	4	5	3
Unit-2.0 Elements of Automobile.	10	**CO2**	15	5	6	4
Unit-3.0 EV Power Transmission System.	14	**CO3**	20	4	10	6
Unit-4.0 Vehicle Control Unit (VCU)	10	**CO4**	15	4	6	5
Unit-5.0 Charging Technologies	6	**CO5**	8	3	3	2
Total Marks	**48**		**70**	**20**	**30**	**20**

Note: Similar table can also be used to design class/mid-term/ internal question papers for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

S. N.	Laboratory Practical Titles	Relevant COs Number(s)	PLA /ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1	Testing of Control Disc Braking system and Control Regenerative Braking system.	CO2	60	30	10
2	Testing of Motors.				
3.	Testing of automotive wiring system.				
4.	Testing of Batteries used in EVs	CO2, CO3	60	30	10
5.	Speed control of Electrical Motors		60	30	10
6.	Connection of Electronic Control Unit components	CO4	60	30	10
7.	Troubleshooting of electronic control unit				
7	Impacts of G2V and V2G	CO 5	30	60	10
8	Demonstration of Charging stations		70	20	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

Note: This table can be used for both the end semester as well as progressive assessment of practicals. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student's performance.

P) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	Disc Braking and Regenerative braking system test rig	Test rig equipment for Demonstration of Disc Braking and Regenerative Braking system operation.	1
2.	Disc Braking System	Test rig / Software for testing the performance of the disc braking system in Half step and Full step braking mode.	1
3.	Induction motor	Induction motor For EV applications with testing kit	2,5
4.	Switched reluctance motor	Switched reluctance motor for EV applications with testing kit	2,5
5.	Permanent magnet (PM) DC motors	Permanent magnet (PM) DC motors for EV applications with testing kit	2,5
6.	Automotive wiring system	Testing facility of automotive wiring system using software /actual EV systems	3

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
7.	Lithium Ion and Lead-acid Batteries	12V, 7Ah with testing setup.	4
8.	Nickel-based batteries (metal hydride and cadmium battery).	12V, 7Ah with testing setup.	4
9.	Battery tester	For testing battery parameters	4
10.	Battery charger	Battery charger for EV	4
11.	Battery Management System	Training kit or simulation for BMS	4
12.	DC-DC Converter	48V to 12V bidirectional DC-DC Converter	4
13.	Power Analyser	To observe the impacts of G2V and V2G	5
14.	BMS setup	For Demonstration & training	4
15.	DC power supply	0-32V	5
16.	Charging Station Simulator	For Demonstration & training purposes.	5
17.	EC Unit with EV subsystems	Electronic Control Unit Hardware parts/ software for demonstrating the Connection of Electronic Control Unit components with EV subsystems.	6,7
18.	Facility to demonstrate the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid.	-	7

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Electric Vehicles: And the End of the ICE age	Anupam Singh	Kindle Edition ASIN: B07R3WFR28
2.	Wireless Power Transfer Technologies for Electric Vehicles (Key Technologies on New Energy Vehicles)	Xi Zhang, Chong Zhu, Haitao Song	Springer Verlag, Singapore; 1st ed. 2022 edition (23 January 2022) ISBN-13: 978-9811683473
3.	Modern Electric, Hybrid Electric, and Fuel Cell Vehicles	EHSANI	CRC Press; Third edition (1 January 2019) ISBN-13: 978-0367137465
4.	Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles	John G. Hayes, G. Abas Goodarzi	Wiley; 1st edition (26 January 2018) ISBN-13: 978-1119063643
5.	New Perspectives on Electric Vehicles	Marian Găiceanu (Editor)	IntechOpen (30 March 2022) ISBN-13: 978-1839696145
6.	Electric and Hybrid Vehicles,	Tom Denton, Taylor & Francis	2nd Edition (2020) ISBN- 9780429296109
7.	Hybrid Electric Vehicles: Energy Management Strategies	S. Onori, L. Serrao and G. Rizzoni	Springer (2016) ISBN: 978-1-4471-6781-5
8.	Electric & Hybrid Vehicles	A.K. Babu	Khanna Publishing House, New Delhi, 1st Edition (2018) ISBN: 9789386173713, 9386173719

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
9.	Power Electronics: Circuits, Devices and Applications,	Rashid, M. H.	Pearson, 3rd edition, (2013) ASIN: B07HB3BM1W
10	Electric Vehicle Engineering	Liana Walker	Clanrye International2023, ISBN-978164729097
11	Electric Vehicles: Current Progress & Technologies	Vanessa Jones	Murphy & Moore Publishing 2023, ISBN 9781649872746
12	20 Electric and Hybrid Vehicles: Principles, Design and Technology	Mary Murphy	Larsen and Keller Education 2023 ISBN 9781641728520

(b) Online Educational Resources:

1. https://www.energy.gov/eere/fuelcells/fuel-cell-systems
2. https://powermin.gov.in/en/content/electric-vehicle
3. https://www.iea.org/reports/electric-vehicles
4. https://www.oercommons.org/search?f.search=Electric+Vehicles
5. https://fame2.heavyindustries.gov.in/Index.aspx

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

(c) Others:

1. Learning Packages on EV
2. EV Users' Guide
3. EV Manufacturers' Manual
4. EV Lab Manuals

S) Course Curriculum Development Team (NITTTR, Bhopal)

- Dr. A. S. Walkey (Coordinator)
- Dr. S. S. Kedar (Co- coordinator)

******

A) **Course Code** : **2000605H/2000608H/2000611H**

B) **Course Title** : Robotics (Advance)

C) **Pre- requisite Course(s)** : Robotics (Basic)

D) **Rationale** :

Efficiency and quality are the demands of industry 4.0. Robotics is a constituent of Industry 4.0 which not only provides the former two but also is beneficial for hazardous and similar challenging situations. The use of robotic technology is developing at a very fast rate in all types of industries whether manufacturing, service or tertiary. Engineers should be competent to use the robotic technology for industry and society advantage. This course aims for the diploma engineers to have advanced skills in robotic applications and use in digital manufacturing.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

CO-1 Plan the use of robots in engineering applications.

CO-2 Elucidate the conceptual place of the robotic components for engineering processes.

CO-3 Use robots for small automatic robotic applications.

CO-4 Compute the economics associated with use of robots in industries.

CO-5 Select appropriate robot for industrial requirements and other applications.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	-	-	3	-	2	-	2		
CO-2	-	2	3	2	-	-	-		
CO-3	3	2	3	-	-	-	2		
CO-4	3	-	-	2	-	-	-		
CO-5	3	2	-	-	2	-	-		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

* PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Board of Study	Course Code	Course Title	Scheme of Study (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
	2000605H /2000608H /2000611H	Robotics (Advance)	03	-	04	02	09	05

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances/ problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Assessment Scheme:

Board of Study	Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
	2000605H /2000608H /2000611H	Robotics (Advance)	30	70	20	30	20	30	200

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- Separate passing is must for progressive and end semester assessment for both theory and practical.
- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done internally (40%) as well as externally (60%). Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

I) Course Curriculum Detailing: This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Define the need and scope of industrial robots. TSO 1b. Describe the concept of robot dynamics with regards to methods for orientation and location of objects. TSO 1c. Analyse robot direct kinematics for the given 2 DOF planar manipulator. TSO 1d. List types of robots TSO 1e. List safety steps while handling the given robot. TSO 1f. Interface robots with the given welding machine. TSO 1g. Interface robots with the given painting machine. TSO 1h. Interface robots with the given assembly machine.	**Unit-1.0 Robot Kinematics, Dynamics and Industrial Applications** 1.1 Definition need and scope of Industrial robots 1.2 Robot dynamics – Methods for orientation and location of objects 1.3 Planar Robot Kinematics – Direct and inverse kinematics for 2 Degrees of Freedom. 1.4 Safety while operating and handling robot	**CO2, CO3**
	1.5 Robot Industrial applications: • Welding Robots-Welding Guns, Welding Electrodes, Welding Power Sources, shielding gases, Robot interfacing • Spray painting Robots, assembly operation, cleaning.	
TSO 2a. Explain the techniques to control robot motion. TSO 2b. Describe the given robot drive system. TSO 2c. Describe the types of grippers. TSO 2d. Design grippers for specific application. TSO 2e. Test the designed gripper for the application. TSO 2f. Use Bar code technology for robotic applications. TSO 2g. Integrate radio frequency identification technology in robotic applications. TSO 2h. Assemble an automated guided vehicle for the given situation using standard components. TSO 2i. Assemble a simple automated storage and retrieval systems (ASRS) for the given situation using standard components.	**Unit– 2.0 Robot Drives, Control and Material Handling** 2.1 Controlling the Robot motion. 2.2 Position and velocity sensing devices. 2.3 Drive systems – Hydraulic and Pneumatic drives 2.4 Linear and rotary actuators and control valves 2.5 Electro hydraulic servo valves, electric drives, motors 2.6 End effectors – Vacuum, magnetic and air operated grippers 2.7 Material Handling; automated guided vehicle systems, automated storage and retrieval systems (ASRS) 2.8 Bar code technology 2.9 Radio frequency identification technology.	**CO2, CO3**
TSO 3a. Differentiate between various work cell layouts. TSO 3b. Select work cell for specific robot with justification. TSO 3c. Analyse robot cycle time. TSO 3d. Explain industrial applications of robotic cell. TSO 3e. Follow safety procedures in robotic cell.	**Unit– 3.0 Robot Cell Design and Application** 3.1 Robot work cell design, control and safety 3.2 Robot cell layouts 3.3 Multiple Robots and machine interference 3.4 Robot cycle time analysis 3.5 Industrial application of robotic cells	**CO3**
TSO 4a. List different programming languages for the robots TSO 4b. Describe artificial intelligence TSO 4c. Write a programme in the required language to operate a robot for the given task. TSO 4d. Optimise robot programming parameters.	**Unit– 4.0 Robot Programming and Economics of Robotization** 4.1 Characteristics of task level languages through programming methods 4.2 Motion interpolation 4.3 Artificial intelligence: Goals of artificial intelligence, AI techniques, problem	**CO1, CO4, CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 4e. Select a robot on the basis of cycle time analysis. TSO 4f. Conduct an economic analysis for use of robots. TSO 4g. Follow testing methods and acceptance rules for industrial robots.	representation in AI 4.4 Problem reduction and solution techniques. 4.5 Application of AI and KBES in Robots 4.6 Selection of Robots; Factors influencing the choice of a robot, selection of robot components, robot performance testing, work cycle time analysis 4.7 Economics analysis for robotics, cost data required for the analysis 4.8 Methods of economic analysis; Pay back method, equivalent uniform annual cost method, return on investment method. 4.9 Testing methods and acceptance rules for industrial robots	
TSO 5a. Describe applications of robots in healthcare and medicine. TSO 5b. Describe applications of robots in Construction industry. TSO 5c. Describe applications of robots in Underground coal mining. TSO 5d. Describe applications of robots in uutilities, military & firefighting operations. TSO 5e. Describe applications of robots in undersea and space TSO 5f. Describe applications of robots in brief in logistics, retail and hospitality, and smart cities. TSO 5g. Describe applications of robots in farming and agriculture in brief explain in brief the use of microrobots, nano robots, soft robots, humanoid robots	**Unit–5.0 Applications in Non-manufacturing Environments** 5.1 Applications of Robots in • Healthcare and medicine • Construction industry • Underground coal mines • Utilities, military & firefighting operations • Undersea • Space • Logistics, • Retail and Hospitality • Smart Cities • Farming and Agriculture 5.2 Overview of Microrobots, nano robots, soft robots, humanoid robots	**CO5**

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical (2000608H):

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSOs 1.1 Identify Wireless Sensor Network. LSOs 2.1 LSOs 1.2 Use wireless sensor Network for different robotic applications	1.	Identify different wireless sensor network in robotics viz. ZigBee, LoRa.	**CO1, CO3**
LSOs 2.2 Identify different Radio Frequency (RF) Controlled Wireless LSOs 2.2 Use Radio Frequency (RF) Controlled Wireless for different robotic applications.	2.	Use different Radio Frequency (RF) Controlled Wireless Robots.	**CO1, CO2**
LSOs 3.1 Identify the different Voice operated robot with speaker identification technology	3.	Examine different voice operated robot with speaker identification technology.	**CO1, CO3**

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSOs 3.2 Use different Voice operated robot with speaker identification technology for different robotic applications.			
LSOs 5.1 Identify the components required for a computer-controlled pick and place robot (wireless). LSOs 5.2 Integrate the components for the required application.	4.	Design a computer-controlled pick and place robot (wireless)	**CO1**
LSOs 6.1 Identify the components required for a Zigbee controlled Boat with wireless video and voice transmission. LSOs 6.2 Integrate the components for the required application.	5.	Design a Zigbee controlled Boat with wireless video and voice transmission.	**CO2, CO3**
LSOs 8.1 Identify the components required for a PC controlled wireless Multipurpose robot for engineering applications. LSOs 8.2 Integrate the components for the required application.	6.	Design a PC controlled wireless Multipurpose robot for simple engineering applications.	**CO2, CO4, CO5**
LSOs 9.1 Identify the components required for an unmanned arial photography LSOs 9.2 Integrate the components for the required application.	7.	Design an unmanned arial photography system.	**CO3, CO5**
LSOs 10.1 Develop a program LSOs 10.2 Simulate palletizing and depalletizing operations through robots.	8.	Develop program for real time (online TPP) Palletizing and Depalletizing operations through robots.	**CO5**
LSOs 11.1 Develop a program LSOs 11.2 Simulate direction control and step control logic for robotization	9.	Develop TPP / Offline program for vision-based inspection for robots.	**CO4, CO5**
LSOs 12.1 Develop a program LSOs 12.2 Simulate robotising an inspection and part assembly.	10.	Program and simulate coordinated identification, inspection and part assembly for robots.	**CO1, CO5**
LSOs 13.1 Develop a program. LSOs 13.2 Simulate obstacle avoidance of robots.	11.	Develop obstacle avoidance robot Programming	**CO1, CO5**
LSOs 14.1 PLC programming. LSOs 14.2 Simulate robotising of welding operation.	12.	Program and simulate welding operation using robot simulation software.	**CO1, CO5**
LSOs 15.1 Simulate robotising of drilling operation.	13.	TPP / Offline program for drilling operation.	**CO1, CO5**
LSOs 16.1Develop a program for an industrial application. LSOs 16.2Execute the robot programme.	14.	Program to execute an industrial robot application using a given configuration.	**CO1, CO5**
LSOs 17.1 Use robot simulation software for Direct Kinematic analysis upto 4-axis robots LSOs 17.2 Correlate the simulated results with respective mathematical calculations.	15.	Analyse Direct Kinematics of 4-axis robot using available software.	**CO2**

L) Suggested Term Work and Self Learning (2000611H): Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. **Assignments**: Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

b. **Micro Projects:** A suggestive list of micro-projects is given here. Similar micro-projects that match the COs could be added by the concerned course teacher. The student should strive to identify eco-friendly or recycled material prior to selection for robotic applications.

1. Develop coin separating robot.
2. Develop robot using radio frequency sensors for material handling.
3. Develop robot for land mine detection.
4. Develop a robot for car washing.

c. Other Activities:

1. Seminar Topics: Recent developments in the industrial applications of robotics
2. Visits: Visit a robotic exhibition.
3. Case Study: Identify a robotic application in automobiles and present a case study
4. Download videos related to simple robotic applications in domestic and industrial purposes.
5. Self-learning topics:
   - Robotic component manufacturers

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate CO attainment.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		**Term Work Assessment (TWA)**			**Lab Assessment (LA)#**	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	**End Theory Assessment (ETA)**	**Term Work & Self- Learning Assessment**			**Progressive Lab Assessment (PLA)**	**End Laboratory Assessment (ELA)**
			Assignments	**Micro Projects**	**Other Activities***		
CO-1	25%	23%	20%	10%	25%	10%	20%
CO-2	20 %	23%	20%	10%	25%	20%	20%
CO-3	15%	17%	20%	25%	25%	20%	20%
CO-4	20%	20%	20%	15%	25%	20%	20%
CO-5	20%	17%	20%	40%	--	30%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

*: Other Activities include self-learning, seminar, visits, surveys, product development, software development etc.

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Number and Title	Total Classroom Instruction (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	**Understanding (U)**	**Application & above (A)**
Unit-1.0 Robot Kinematics, Dynamics and Industrial Applications	12	**CO2, CO3**	16	6	5	5
Unit– 2.0 Robot Drives, Control and Material Handling	10	**CO2, CO3**	16	4	8	4

Unit– 3.0 Robot Cell Design and Application	8	**CO3**	12	2	4	6
Unit– 4.0 Robot Programming and Economics of Robotization	10	**CO1, CO4, CO5**	14	4	4	6
Unit– 5.0 Applications in Non-manufacturing Environments	8	**CO5**	12	4	4	4
Total Marks	**48**		**70**	**20**	**25**	**25**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Identify different wireless sensor network in robotics viz. ZigBee, LoRa.	CO1, CO3	40	40	20
2.	Use different Radio Frequency (RF) Controlled Wireless Robots.	CO1, CO2	40	40	20
3.	Examine different voice operated robot with speaker identification technology.	CO1, CO3	40	40	20
4.	Design a computer-controlled pick and place robot (wireless)	CO1, CO4	40	40	20
5.	Design a Zigbee controlled Boat with wireless video and voice transmission.	CO2, CO3	40	40	20
6.	Design a PC controlled wireless Multipurpose robot for simple engineering applications.	CO3, CO4	40	40	20
7.	Design an unmanned arial photography system.	CO3, CO5	40	40	20
8.	Develop program for real time (online TPP) Palletizing and Depalletizing operations through robots.	CO5	40	40	20
9.	Develop TPP / Offline program for vision-based inspection for robots.	CO4, CO5	40	40	20
10.	Program and simulate coordinated identification, inspection and part assembly for robots.	CO1, CO5	40	40	20
11.	Develop Obstacle avoidance robot Programming	CO1, CO5	40	40	20
12.	Program and simulate welding operation using robot simulation software.	CO1, CO5	40	40	20
13.	TPP / Offline program for drilling operation.	CO1, CO5	40	40	20
14.	Program to execute an industrial robot application using a given configuration.	CO1, CO5	40	40	20
15.	Analyse Direct Kinematics of 4-axis robot using available software.	CO2, CO3	40	40	20

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies: Different Instructional/Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources(OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S.No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/ Practical Number

1.	6 Axis Articulated Robot (Material Handling)- 1 No	• Articulated Type
		• Controlled axis: 6-axes (J1, J2, J3, J4, J5, J6)
		• Reach: 717 mm
		• Installation Floor, Upside-down (Angle mount)
		• Motion range (Maximum Speed)
		  • J1 Axis Rotation7.85 rad/s
		  • J2 Axis Rotation 6.63 rad/s
		  • J3 Axis Rotation 9.08 rad/s
		  • J4 Axis Rotation 9.60 rad/s
		  • J5 Axis Rotation 9.51 rad/s
		  • J6 Axis Rotation 17.45ras/s
		• Max. load capacity Wrist: 4Kg
		• Allowable Load moment 16.6 N-m at wrist J4 Axis, J5 Axis, J6 Axis
		• Allowable Load inertia).47 kg-m^2 at wrist J4 Axis J5 Axis, J6 Axis
		• Repeatability: +/- 0.05mm
		• Mass: 21 Kg Minimum
		• Installation environment: Ambient temperature: 0 – 45°C
		• Ambient humidity: Normally 75%RH or less. No dew, nor frost allowed.
		• Vibration Acceleration: 4.9 m/s2 (0.5G or less)
			1, 2, 3, 12

2.	6 Axis Articulated Robot (General Purpose- Welding, Assembly, Drilling) - 1 No	Link 1: 300 mm Link 2: 300 mm Joint actuator: DC Stepper Motor Transmission: Timing Belt Drive Position feedback: Proximity Switch Gripper actuator: Pneumatic Weight of robot: 50 Kg. Accuracy: ±0.3 Repeatability: ±0.2Tip Velocity range: 500 mm / minPay load capacity: 2 kg (including griper) J1 - Waist: ± 140°J2 - Shoulder: -100 - 60°J3 - Elbow: - 70 + 10°J4 - Wrist rotate: ± 70°J5 - Wrist pitch: ± 35°J6 - Wrist roll: ± 180°External I/O8 Programmable digital inputs8 Programmable digitaloutputs	8, 9, 14
3.	A mounted vision system with software (Free open source Robot simulation software)	Integrity Serial Bus System, CAN to Build Intelligent Device Network, Open Hardware Platform, Arduino, to control Robot sub-Systems of motor-sensor, movable Omni Wheel of Omni-Directional, Actuator operation control by DC Encoder Motor, DC-Motor control and operation by Accelerometer, Gyro, Ultrasonic and PSD sensor, Androx Studio; brushless ILM 70×10 Robo Drive DC motor; sensor-actuator units of ARMAR-4; SD-25-160-2A-GR-BB	3, 4, 5, 11

S.No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/ Practical Number
		Harmonic Drive reduction gear unit high gear ratio of 160: 1; structural parts (white) are made out of high-strength aluminum, Hollow shaft with strain gauges for torque sensing, motor's magnetic incremental encoder (AMS5306), digital buses (SPI or 12C); Motor interfacePCB includes a 13-Bit temperature-to-digital converter with a temperature range from −40°C to 125°C (Analog Devices ADT7302)	
4.	6-axis Robotics Trainer	Programmable robotic arm with an interactive frontpanel. Software to demonstrates functioning of the trainer as well as allows a user to develop their own programs. NV330; 8 bit microcontroller to ARM processors**;** Record and Play capability**;** Optional interfacing with PL**C;** Touch operated ON/OFF Switch**;** Auto set to home position**;** Applications can be developed**;**Data acquisition using USB	3, 4, 5, 13
5.	E-Yantra Firebird kit	• Fire Bird V 2560 Robot • Spark V Robot • Fire Bird V P89V51RD2 adapter card • Fire Bird V LPC2148 adapter card • LSM303 3 axis digital accelerometer and 3 axes magnetometers • L3G4200 3 axis digital gyroscope • Gyroscope, accelerometer and GPS interfacing module for the robot • GPS receiver • Zigbee Modules 100m range • Zigbee Modules Adapter • Metal-gear Servo Motors • Servo Motor Based Gripper kit for the Fire Bird V robot • Sharp infrared range sensor (10cm to 500cm) • Arduino Uno/Nano • Hexapod • 16 Programming Software (AVR studio, Keil, AVR Boot loader, Flash Magic)	1, 3, 5, 6, 7, 10
6.	Robot simulator for Robotics	Educational networking licensed Robotic system with simulation software	2, 8, 10
7.	Assorted sensors	Optical encoders, Acoustic sensors ,IR, Potentiometer, RTD, Thermistor, strain gauge, piezoelectric, etc.	4
8.	Vision equipment	Camera, Imaging Components: Point, Line, Planar and Volume Sensors	1, 4, 10
9.	Raspberry Pi kit	1.2GHz quad-core Broadcom BCM2837 CPU with 1GB DDR2 RAM with in-built Wi-Fi & Bluetooth Video Core IV 3D graphics core 40 pin extended pins - with 27 GPIO pins Micro SD slot Multiple ports: Four USB ports, full sized HDMI, four pole stereo output and composite video port, CSI camera port and DSI display port 10/100 BaseT Ethernet Micro-USB, power source 5V, 2A	7, 9

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Introduction to Robotics Mechanics and Control	John Craig	Pearson Education 978-9356062191
2.	Robotics and controls	Mittal R.K., Nagrath I.J.	Tata McGraw Hill Education Pvt. Ltd.; 2017; **978**-0070482937
3.	Robotics and Image Processing: An Introduction	Janaki Raman. P. A	Tata McGraw Hill Publishing company Ltd., 1998; 978-0074621677
4.	Industrial Robotics -Technology, Programming and Applications	Nicholas Odrey, Mitchell Weiss, Mikell Groover Roger Nagel, Ashish Dutta	McGraw Hill Education; 2nd Edition; 978 -1259006210
5.	Robotic Engineering: an integrated approach	Richard D. Klafter, Thomas A. Thomas A. Chmielewski, Michael Negin	Prentice Hall of India, N. Delhi, 2009; 978-8120308428
6.	Industrial Robotics Technology, Programming and Applications	Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey	McGraw-Hill Education, Second Edition, 978-1259006210
7.	Robotics	Appuu Kuttan K. K.	Dreamtech Press, First Edition, 2020, 978-9389583281
8.	Introduction to Robotics: Analysis, Control, Applications	Saeed B. Niku	Wiley; Second Edition, 978-8126533121
9.	Essentials of Robotics Process Automation	S. Mukherjee	Khanna Publication, First Edition, 978-9386173751
10.	Robotics	R R Ghorpade, M M Bhoomkar	Nirali Prakashan 978-9388897020
11.	Mechatronics: Engineering Fundamentals	Allie Weaver	Murphy & Moore Publishing 2022 ISBN 9781649872758
12.	Elements of Robotics	Greg Scott	States Academic Press 2022 ISBN 9781649649261
13.	Robotics: Design, Construction and Applications	Allie Weaver	Willford Press 2022 ISBN 9781682860944
14.	Modern Robotics: Mechanics, Systems and Control	Julian Evans	Larsen and Keller Education 2022 ISBN 9781641728515
15.	Introduction to Mechatronics	Randy Dodd	Larsen and Keller Education 2022 ISBN 9781641728493
16.	Introduction to Robotics	Julian Evans	Larsen and Keller Education 2022 ISBN 9781641728503

(b) Online Educational Resources:

1. https://web.iitd.ac.in/~saha/ethiopia/appln.pdf
2. https://nptel.ac.in/courses/112105249
3. https://www.robotsscience.com/industrial/industrial-robots-types-applications-benefits-and-future/
4. https://www.marian.ac.in/public/images/uploads/pdf/online-class/MODULE-6%20ROBOTICS%20INDL_APPLNS-converted.pdf
5. https://forcedesign.biz/blog/5-common-industrial-robot-applications
6. https://www.hitechnectar.com/blogs/top-industrial-robotics-applications-role-of-robots-in-manufacturing/
7. https://en.wikipedia.org/wiki/Industrial_robot

8. https://www.youtube.com/watch?v=fH4VwTgfyrQ
9. https://www.youtube.com/watch?v=aW_BM_S0z4k
10. https://www.automate.org/industry-insights/smarter-robot-grasping-with-sensors-software-the-cloud
11. https://robots.ieee.org/robots/?t=all
12. https://www.youtube.com/watch?v=fc_Cynqr6jM

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested OER, before use by the students.

(c) Others:

1. Learning Packages:

- https://www.edx.org/learn/robotics
- https://www.coursera.org/courses?query=robotics
- https://www.udemy.com/topic/robotics/
- https://library.e.abb.com/public/9a0dacfdec8aa03dc12578ca003bfd2a/Learn%20with%20ABB.%20Robotic%20package%20for%20education.pdf

2. Users' Guide:

- https://roboindia.com/store/DIY-do-it-your-self-educational-kits-robotics-embedded-system-electronics
- https://www.robomart.com/diy-robotic-kits
- https://www.scientechworld.com/robotics

3. Lab Manuals:

- http://www-cvr.ai.uiuc.edu/Teaching/ece470/docs/ROS_LabManual.pdf
- https://www.jnec.org/labmanuals/mech/be/sem1/Final%20Year%20B.Tech-ROBOTICS%20LAB%20%20MANUAL.pdf

S) Course Curriculum Development Team (NITTTR, Bhopal)

- Dr. Nishith Dubey (Coordinator)
- Prof. (Mrs.) Susan S. Mathew (Co-Coordinator)
- Dr. Sharad Pradhan

******

BUILDING ELECTRIFICATION LABORATORY

(ELECTRICAL ENGINEERING GROUP)

Subject Code 2020608A	PRACTICAL						Credits
	No. of Periods Per Week			Full Marks	:	50	02
	L	T	P/S	Internal (PA)	:	**20**	
	—	—	04	External (ESE)	:	30	
	—	—	—				

Course objectives:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Design electrical installation systems in building complexes

CONTENTS: PRACTICAL

Practical's:

1. Prepare series testing board.
2. Select the electric wire using measuring and testing instruments for particular applications.
3. Identify cables of different current ratings.
4. Prepare wiring installation on a board showing control of one lamp, one fan and one socket from one switch board in PVC surface conduit wiring system.
5. Prepare wiring installation on aboard.
6. Control one lamp from two different places using PVC surface conduit wiring system.
7. Prepare wiring installation on a board. Control one lamp from three different places using PVC surface conduit wiring system.
8. Prepare wiring installation on aboard.
9. Perform go-down wiring for three blocks using PVC casing capping.
10. Design 2 BHK residential installation scheme and estimate the material required. And draw the details required for installation on A4 size sheet.
11. Test wiring installation using megger.

Course outcomes:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry-oriented COs associated with the above-mentioned competency:

CO 1: Select accessories, wires, cables and wiring systems for electrification.

CO 2: Design electrical wiring installation system for residential unit.

CO 3: Design proper illumination scheme for residential unit.

CO 4: Prepare wiring layouts on wiring board.

CO 5: Locate and diagnose faults in electrical wiring installation.

CO 6: Do proper earthing for building electrification.

*****

TERM WORK
SEMINAR

Subject Code	TERM WORK						Credits
2020609	No. of Periods Per Week			Full Marks	:	50	02
	L	T	P/S	Internal (PA)	:	15	
	—	—	4	External (ESE)	:	35	
	—	—	—				

Course objectives:

A seminar is a form of academic instruction, either at an academic institution or offered by a commercial or professional organization. It has the function of bringing together small groups for recurring meetings, focusing each time on some particular subject, in which everyone present is requested to participate. This is often accomplished through an ongoing Socratic dialogue with a seminar leader or instructor, or through a more formal presentation of research. It is essentially a place where assigned readings are discussed, questions can be raised and debates can be conducted.

The term *seminar* is also used to describe a research talk, often given by a visiting researcher and primarily attended by academics, research staff, and postgraduate students. Seminars often occur in regular series, but each seminar is typically given by a different speaker, on a topic of that speaker's choosing. Such seminars are not usually a part of a course of study and are therefore not usually associated with any assessment or credit. The term *colloquium* is often used interchangeably with seminar in this sense.

******

TERM WORK

(ELECTRICAL ENGINEERING GROUP)

MAJOR PROJECT

Subject Code	TERM WORK						Credits
2020610	No. of Periods Per Week			Full Marks	:	100	03
	L	T	P/S	Internal (PA)	:	30	
	—	—	6	External (ESE)	:	70	
	—	—	—				

Course objectives:

The projects if done right can help enthusiastic electrical engineering students to develop the skills/profile needed for an exciting career in core technologies. Since practical skills are very important to work on core industries, experts tend to analyse candidate's performance based on their project experience during the interviews.

These projects provide an excellent opportunity to learn and showcase your practical skills to your future interviewers easily. If spent qualitatively you can build a very innovative electrical project and get a great learning experience. By doing so, you will not only develop an innovative project but also develop valuable skills needed for a successful career in core technologies related to electrical engineering. The best way to master a subject is by doing projects. Through a project you not only get a deeper understanding of the subject but also gain hands-on practical experience. If you are looking to do internships in college, the best way to catch the companies' attention is through projects.

Projects are generally done as a combined team effort. Two or more students work under a guide or a staff to get a certain result. By doing a project, you will

- Understand your subject better
- Get practical experience
- Chance to showcase your skills
- Learn about team work, communication skills and responsibilities

When companies look for interns, they prefer students who have good understanding of the subject with at least some hands on experience. The best to achieve both is by doing projects.

There is no fixed time to do a project. You can do it right from your first year in college. If you are looking to do a technical project, then the best time to start would be mid second year. It's not mandatory that you do many projects but make sure that you at least do one project. A lot of students tend to do few small projects from their second year and do a big project in their final year. By showcasing your projects, you can even look for internships while in college.

You can do any kind of projects based on your interests or subjects. The best way to go about this is to figure out what you are interested in. So the first step is to find your interest and then do projects in your area of interest.

Find your area of interest and then do a project in that field.

You can start by exploring different areas and then pick the field in which you are interested in. You can learn more about it and start working on small problems.

Few examples:

1.HomeAutomationusingIoT 2.BatteryManagement SystemusingArduino

3. Smart Energy Meter using GSM

4. Implementation of a Web of Things Based Smart Grid to Remotely Monitor and Control Renewable Energy Sources

5. Home Automation System

6. Enerbee - Example of an Advanced Metering Infrastructure based on Zigbee

7. Solar & Smart Energy Systems

8. Power Factor Metering System using Arduino

9. Automatic Solar Tracker

10.UsingArduinoDevelopment Platform in the Diagnosis of AC Electrical Machines

11.ArduinoProjects

12.DesignandImplementationof Real Time Transformer Health Monitoring System using Gsm Technology

13.Smart EnergyProjects

14.DesignandImplementationofanAdvanced Security System - Invisible Eye (Power Saving System)

15.PCB Manufacturing

16.FootStepbasedPower GenerationandMulti- Purpose Optimization

17.MATLABfor Engineers

18.Universal Electrical Power Generationand Multipurpose Optimization–Solar,Windand Rain

19.Digital Signal Processing using MATLAB

20.Electrical SubstationScrutinizingand Controlling Device from Remote Area

21.SimscapeElectrical usingMATLAB

22.WirelessPower Transmission

23.ImageProcessingusingMATLAB

24.Transformer IndustrialParametersManagement Control System andIntimation toElectricity Board

25.Advanced Image Processing using MATLAB

26.OnlineSpeedControl ofDCMotorwithHigh Speed Network

27.Digital Signal Processing using Python

28.EnergyScrutinySystemwith AutoLoad

29.Circuit DesignwithProteus

30.Talking Energy Meter

31.PCB Design and Simulation with KiCAD

32.MicroControllerbasedIntelligent Multi Timer System for Industrial Automation

33. Lab VIEW for Engineers

34. Auto Digital-Speed Indicator with Speed Control

35. PLC Programming for Engineers

36. GSM and PIR Sensor based Light Controller and Networked Safety System

37. Smart Traffic Lighting System

38. Electric Field and Ultrasonic Sensor based Security System

39. Automation using PLC

40.Mobile Controlled DC Motor Speed Controller

Similar many on related tobranch.

*****

TERM WORK
Course Under MOOCS/ NPTEL/OTHERS

Subject Code	TERM WORK						Credits
2020611	No. of Periods Per Week			Full Marks	:	50	01
	L	T	P/S	Internal (PA)	:	20	
	—	—	2	External (ESE)	:	30	
	—	—	—				