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	EXAMINATION-SCHEME						
			Periods per Week	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	EXAMINATION-SCHEME					
			Periods per Week	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	EXAMINATION-SCHEME				
			Periods per Week	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.

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Elective III

ELECTRICAL ESTIMATING AND COSTING

(ELECTRICAL ENGINEERING GROUP)

Subject Code	Theory						Credits
2020503B	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.

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.

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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.

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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.

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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

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Elective IV

ELECTRIC TRACTION
(ELECTRICAL ENGINEERING GROUP)

Subject Code 2020504C	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:

- 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.

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 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.

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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)

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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. TSO 3e.	Explain Radio communication unit used in drone. Explain the communication of Flight controller board with motor, ESC and sensors with suitable diagram	Radio Communication • Transmitter and Receiver for radio signal	
TSO 4a. TSO 4b. TSO 4c.	Describe utility of different communication port used in drone. Identifydifferent types of connectors and write their specifications. Explain the use of drone simulator software and hardware.	**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 5a. TSO 5b. TSO 5c. TSO 5d.	Write basic code in Python. Explain structure and components of a Python program. write syntax of loops and decision statements in Python. Explain steps to create functions and pass arguments 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**

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)

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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.)

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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)
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		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.

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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)

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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** 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 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(PL	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)	Units	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)

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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:

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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 PL**C;** 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)

Subject Code 2020506	Practical			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 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]

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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)

Subject Code 2020507	Practical			No of Period in one session:			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:

- 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]

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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)

Subject Code 2020508A	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:

- 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)

Subject Code 2020508B	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:

- 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)

Subject Code 2020509A	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 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	Practical			No of Period in one session:30			Credits
2020509B	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

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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

Subject Code	Term Work			No of Period in one session:30			Credits
	No. of Periods Per Week			Full Marks	:	50	
2020511	L	T	P/S	Internal (PA)	:	20	01
	-	-	02	External (ESE)	:	30	

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