Curriculum of Diploma Programme

in

Electrical Engineering

J.P. Institute Of Technology

Department of Science, Technology and Technical Education (DSTTE), State Govt. of Bihar

State Board of Technical Education (SBTE), Bihar

Semester - IV

Semester – IV
Teaching & Learning Scheme

Board of Study	CourseCodes	CourseTitles	Teaching & Learning Scheme (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
	2420401	**Power Electronics**	3	-	4	2	9	6
	2420402	**Microprocessor and Microcontrollers**	3	-	4	2	9	6
	2420403	**A C Machines**	3	-	4	2	9	6
	2420404	**Control System and PLC**	3	-	4	2	9	6
	2420405	**Electrical Software Lab** (Drawing & CAD, MATLAB & Simulink)	-	-	4	2	6	3
	2400107	**Professional Ethics** (Non-exam course)	1	-	-	-	1	1
	2400207	**Indian Constitution** (Common for All Programmes)	1	-	-	-	1	1
	2400108	**Essence of Indian Knowledge System and Tradition** (Common for All Programmes)	1	-	-	-	1	1
Total			**15**	**-**	**20**	**10**	**45**	**30**

Legend:

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

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

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

TW: Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

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

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

Semester - IV

Assessment Scheme

Board of Study	Course Codes	Course Titles	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
	2420401	**Power Electronics**	30	70	20	30	20	30	200
	2420402	**Microprocessor and Microcontrollers**	30	70	20	30	20	30	200
	2420403	**A C Machines**	30	70	20	30	20	30	200
	2420404	**Control System and PLC**	30	70	20	30	20	30	200
	2420405	**Electrical Software Lab** (Drawing & CAD, MATLAB & Simulink)	-	-	20	30	20	30	100
	2400107	**Professional Ethics** (Non-exam Course)	25	-	-	-	-	-	25
	2400207	**Indian Constitution** (Common for All Programmes)	25	-	25	-	-	-	50
	2400108	**Essence of Indian Knowledge System and Tradition** (Common for All Programmes)	25	-	-	-	-	-	25
Total			**195**	**280**	**125**	**150**	**100**	**150**	**1000**

Legend:

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

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

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

A) Course Code : **2420401(T2420401/P2420401/S2420401)**

B) Course Title : Power Electronics

C) Pre- requisite Course(s) : Fundamentals of Electronics Engineering/Basic Electrical Engineering/Electrical Circuit and Network

D) Rationale :

Power electronics deals with the applications of solid-state electronics for processing of high voltages and currents to deliver power that supports a variety of needs of modern Industrial and domestic applications. The function of power electronics is to convert and control the electric power with converters modifying the primary characteristics of electrical power such as voltage, current and frequency in a form that is optimally suited to the load. Power electronics also play a crucial role in the integration of renewable energy sources into the electrical grid by enabling efficient and reliable power conversion, improved grid integration, and increased adoption of renewable energy sources. In this era of industrial automation and with the advancement of power electronics devices, the conventional control and relays have now become obsolete and are replaced by electronic control and relays, employing solid state power semiconductor devices. This core course is designed to provide essential theoretical and practical skills to use power electronics to control electrical machines and devices in commercial and industrial sector.

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, Psycho motor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

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

CO-1 Test the performance of Power Electronics devices.
CO-2 Maintain Turn on and Turn off circuit for a thyristor.
CO-3 Use relevant Phase Controlled rectifier for a given situations.
CO-4 Select a suitable chopper for a given applications.
CO-5 Test the performance of inverter, Cycloconverter and AC voltage controller.

F) Suggested Course Articulation Matrix (CAM):

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

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

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Board of Study	Course Code	Course Title	Scheme of Study (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
Electrical Engineering	**2420401**	Power Electronics	03	-	04	02	09	06

Legend:

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

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

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H) Assessment Scheme:

Board of Study	Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
Electrical Engineering	**2420401**	Power Electronics	30	70	20	30	20	30	200

Legend:

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

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

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

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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), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: T2420401

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Sketch standard symbol of the given Power electronic devices. *TSO 1b.* Explain the working principle of the given power electronic devices with the help of characteristic curve. *TSO 1c.* Explain different protection circuits used in SCR. *TSO 1d.* Interpret the characteristics of the given power electronic devices. *TSO 1e.* Describe the procedure to choose suitable power electronic device for the given switching application.	**Unit-1.0 Power Electronics Devices**. 1.1 Silicon Controlled Rectifier (SCR): Construction, principle of operation, characteristic curve, two transistor analogy, Switching characteristics and triggering methods. 1.2 Rating and Protection: over voltage, over current, snubber circuit. 1.3 Series and parallel operation of SCRs: String efficiency. 1.4 DIAC, TRIAC: Construction, Operation, characteristic curves and applications. 1.5 Power BJT, MOSFET, IGBT: Construction, Operation, characteristic curves and applications.	**CO1**
TSO 2a. Explain the given triggering method of SCR. *TSO 2b.* Explain the given turn off method of SCR. *TSO 2c.* Describe the given class of commutation circuit.	**Unit-2.0 Turn-on and Turn-off methods of Thyristors** 2.1 SCR Turn-on methods: High Voltage triggering, thermal triggering, illumination triggering, dv/dt triggering, Gate triggering 2.2 Gate trigger circuits: Resistance and Resistance capacitance circuits, 2.3 SCR triggering using UJT Relaxation Oscillator and Synchronized UJT circuits. 2.4 SCR Turn-Off methods: Natural and forced commutation, 2.5 Class A, Class B, Class C, Class D commutation.	**CO1, CO2**
TSO 3a. Determine the average output voltage for a single-phase half wave controlled rectifier for the given load. TSO 3b. Explain the working principle of full converter for the given load, with and without freewheel diode. TSO 3c. Justify the need of freewheeling diode in converter. TSO 3d. Explain working & various waveform of single-phase semi converter for various loads. TSO 3e. Explain the working of three phase half wave-controlled converter with a neat sketch for the given load. TSO 3f. Explain the working of a Dual converter TSO 3g. Describe the procedure to select a suitable converter for the given application	**Unit-3.0 Phase Controlled Rectifier** 3.1 Phase control: firing angle, conduction angle 3.2 Single Phase Fully Controlled Half Wave Converter: With R, RL and RLE load: Circuit diagram, working, input- output waveform, equations for DC outputs. 3.3 Single-phase full-wave mid-point and bridge converter with R load, RL load, RL load with DC source: Circuit diagram, working, input- output waveform, equations for DC outputs 3.4 Single-phase semi converter with R, RL load with DC source: Circuit diagram, working, input-output waveform, equations for DC outputs 3.5 Three-phase half wave converter with R load: Circuit diagram, working, input- output waveform. 3.6 Three-phase full wave converter with R load: Circuit diagram, working, input- output waveform. 3.7 Dual Converter.	**CO2, CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 4a. Explain the given control techniques of Chopper *TSO 4b.* Classify choppers based on the given criteria. *TSO 4c.* Explain the working principle and waveforms for the given type of chopper along with neat sketches. *TSO 4d.* Calculate duty cycle, output voltage and other parameters for the given type of chopper *TSO 4e.* Explain working principle of the given Class of chopper along with neat sketches. *TSO 4f.* Explain the working of Buck, Boost and Buck boost converter. *TSO 4g.* Explain the given commutation method of chopper.	**Unit-4.0 Chopper** 4.1 Chopper: Working Principle and its applications 4.2 Control Techniques: Constant Frequency and Variable Frequency System 4.3 Classification of Choppers: - Step Up and Step-down choppers - Class A, Class B, Class C, Class D and Class E chopper 4.4 Buck, Boost and Buck-boost converter 4.5 Commutation methods of chopper: Load commutation and Auxiliary commutation.	**CO2, CO4**
TSO 5a. Explain working of the given type of bridge inverter for R and RL loads. *TSO 5b.* Explain the working of series and parallel inverter. *TSO 5c.* Describe Voltage Source and Current Source Inverter. *TSO 5d.* Explain working of three phase VSI in 180' and 120'mode with the help of various waveforms. *TSO 5e.* Explain the given Voltage control methods of Inverter. *TSO 5f.* Describe the given type of single phase Cycloconverter giving its application. *TSO 5g.* Explain working principle of single phase Cyclo converter (Midpoint and bridge configuration with R load). *TSO 5h.* Describe working principle and application of single-phase AC voltage controller.	**Unit-5.0 Inverter, Cycloconverter and AC Voltage Controller** 5.1 Single Phase Bridge Inverter - Half and full bridge inverter with R and RL load. 5.2 Basic series and parallel Inverter - Operation and its application. 5.3 Voltage and Current Source Inverter 5.4 Three phase bridge inverters: Three phase 180 Degree mode VSI Circuit diagram, working, input- output wave forms. 5.5 Three phase 120-Degree mode VSI Circuit diagram, working, input- output wave forms. 5.6 Voltage control methods (Pulse Width Modulation techniques) of Inverter - Single pulse width modulation - Multiple pulse width modulation - Sinusoidal pulse width modulation 5.7 Single phase Cyclo-converter: working principle of Midpoint and bridge Configuration with R load. 5.8 Step up and step-down single phase Cyclo-converter and its applications. 5.9 Working principle and applications of a single-phase AC voltage controller.	**CO5**

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2420401

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Identify the terminals of SCR. *LSO 1.2* Test the performance of the given SCR.	1.	V-I Characteristics of SCR.	CO1
LSO 1.3 Test the performance of IGBT.	2.	Characteristics of IGBT.	CO1
LSO 1.4 Test the performance of power MOSFET.	3.	Characteristics of power MOSFET.	CO1
LSO 1.5 Test the performance of the given DIAC and determine the breakover voltage	4.	Characteristics of DIAC.	CO1
LSO 1.6 Test the performance of TRIAC for the given AC load control.	5.	Characteristics of TRIAC.	CO1
LSO 2.1 Design and test the R and RC triggering circuit to trigger the given SCR.	6.	R and RC triggering circuits of SCR.	CO1, CO2
LSO 2.2 Test the performance of UJT triggering circuits of SCR.	7.	UJT triggering circuits of SCR.	CO1, CO2
LSO 2.3 Test the performance of given forced commutation circuit (A, B, C, D and E)	8.	Forced commutation circuit (A, B, C, D and E)	CO1, CO2
LSO 3.1 Test the Performance of a half wave-controlled rectifier comprising of SCR for the given load with freewheeling diode.	9.	Performance of a half wave-controlled rectifier comprising of SCR for R, RL load and RL load with freewheeling diode.	CO2, CO3
LSO 3.2 Test the Performance of a full wave-controlled rectifier comprising of SCR for the given load with freewheeling diode.	10.	Performance of a full wave-controlled rectifier comprising of SCR for R, RL load and RL load with freewheeling diode.	CO2, CO3
LSO 4.1 Test the Performance of buck converter with different values of duty cycle for the given load.	11.	Performance of buck converter with different values of duty cycle for a given R and RL load.	CO2, CO4
LSO 4.2 Test the Performance of a boost converter at different duty cycle for the given load.	12.	Performance of a boost converter at different duty cycle for a given R load.	CO2, CO4
LSO 5.1 Test the performance of single-phase half bridge VSI feeding R load.	13.	Performance of single-phase half bridge VSI feeding R load.	CO5
LSO 5.2 Test the performance of single-phase full bridge VSI feeding RL load.	14.	Performance of single-phase full bridge VSI feeding RL load.	CO5
LSO 5.3 Measure the input to output frequency of a single phase to single phase step down Cycloconverter.	15.	Measurement of frequency of a single phase to single phase step down Cycloconverter.	CO5
LSO 5.4 Measure the input to output frequency of a single phase to single phase step up cyclo-converter.	16.	Measurement of frequency of a single phase to single phase step up cyclo-converter.	CO5
LSO 5.5 Measure the output load voltage of a single-phase AC voltage controller using on- off circuit.	17.	Measurement of output load voltage of a single-phase AC voltage controller using on-off circuit.	CO5
LSO 5.6 Measure the output load voltage of a single-phase AC voltage controller using phase angle control for a Rand RL load.	18.	Measurement of output load voltage of a single-phase AC voltage controller using phase angle control for a R and RL load.	CO5

L) Suggested Term Work and Self Learning: S2420401 Some sample suggested assignments, micro project and other activities are mentioned here for reference.

I. **Assignments**:

1. List various applications in our daily life where power Electronics devices and circuits are used.
2. Collect information about the ratings of Thyristor family and submit report on it.
3. List the use of triggering and commutation circuits in various devices.
4. Solve numerical of phase-controlled rectifier (single phase half wave/full wave)
5. Solve numerical based on Buck and Boost converter.
6. List the applications of Chopper circuits.
7. List the applications, merits and demerits of VSI and CSI
8. List the types of storage batteries used in UPS, advantages and disadvantages of each type

II. Micro Projects:

1. Design a circuit to test whether a given SCR is healthy or unhealthy.
2. Build and test fan speed regulator circuit using DIAC, TRIAC.
3. Build the circuit for speed control of 12 V DC shunt motor using IGBT.
4. Build temperature controller using thermistor and thyristor.
5. Simulate control of intensity of light using phase control.
6. Build and test inverter circuit for emergency lighting.
7. Collect information on the rating of commercially available various specification of available power devices and prepare a report on it.

III. Other Activities:

1. Seminar Topics:

i. Various Phase controlled rectifiers.
ii. Applications of Chopper circuits
iii. Applications of Cycloconverter
iv. AC Voltage Controller
v. Online UPS

2. Visits:

i. Survey the market and submit the report of available choppers, inverters, dual converters, and Cycloconverters.
ii. Visit the nearby power grid substation to investigate the use of power electronics devices and submit a report on it.

3. Self-learning topics:

i. Various industrial control circuits.
ii. Applications of power electronics
iii. Maintenance steps involved for a UPS system.
iv. various types of converter available for solar power application.

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

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	20%	20%	25%	100%	20%	30%	20%
CO-2	15%	15%	15%		20%	15%	20%
CO-3	25%	25%	20%		20%	15%	20%
CO-4	15%	15%	20%		20%	15%	20%
CO-5	25%	25%	20%		20%	25%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

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

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Power Electronics Devices	12	CO1	14	5	5	4
Unit-2.0 Turn on & Turn off of thyristors	6	CO1, CO2	10	3	3	4
Unit-3.0 Power Controlled Rectifier	12	CO2, CO3	18	5	5	8
Unit-4.0 Chopper	6	CO2, CO4	10	2	4	4
Unit-5.0 Inverter, Cycloconverter and AC Voltage Controller	12	CO2, CO5	18	5	5	8
Total	**48**	-	**70**	**20**	**22**	**28**

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	V-I Characteristics of SCR.	CO1	50	40	10
2.	Characteristics of IGBT.	CO1	50	40	10
3.	Characteristics of power MOSFET.	CO1	50	40	10
4.	Characteristics of DIAC.	CO1	50	40	10
5.	Characteristics of TRIAC.	CO1	50	40	10
6.	R and RC triggering circuits of SCR	CO1, CO2	40	50	10
7.	UJT triggering circuits of SCR	CO1, CO2	40	50	10
8.	Forced commutation circuit (A, B, C, D and E)	CO1, CO2	40	50	10
9.	Performance of a half wave-controlled rectifier comprising of SCR for R, RL load and RL load with freewheeling diode.	CO2, CO3	50	40	10
10.	Performance of a full wave-controlled rectifier comprising of SCR for R, RL load and RL load with freewheeling diode	CO2, CO3	50	40	10
11.	Performance of buck converter with different values of duty cycle for a given R and RL load	CO2, CO4	50	40	10
12.	Performance of a boost converter at different duty cycle for a given R load.	CO2, CO4	50	40	10
13.	Performance of single-phase half bridge VSI feeding R load	CO5	50	40	10
14.	Performance of single-phase full bridge VSI feeding RL load	CO5	50	40	10
15.	Measurement of frequency of a single phase to single phase step down cycloconverter	CO5	50	40	10
16.	Measurement of frequency of a single phase to single phase step up cyclo-converter.	CO5	40	50	10
17.	Measure the output load voltage of a single-phase AC voltage controller using on- off circuit	CO5	40	50	10
18.	Measurement of output load voltage of a single-phase AC voltage controller using phase angle control for a R and RL load.	CO5	40	50	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	SCR	12A,600V, Type TY616	1
2.	MOSFET	V_{DS} 650V, 35 Amp, Type SPW35N60C3	3
3.	IGBT	V_{CE} 600V, 33-amp, Type IRGP50B60PD	2
4.	TRIAC	BT136, 10A,600V	5
5.	DIAC	DB32, Rated current: 2 A, Power: 0.15 W	4
6.	Passive components	Inductors, resistors, voltage and current sources, capacitors, and transformers	1-18
7.	Resistor	I kohm to 10 kohm, 1 Watt	1-18
8.	Inductor	300mH,2A,	9,10,11,14
9.	Variable inductor	10mH – 5mH – 0 – 5mH – 10mH/2 Amps	1-18
10.	Capacitors	6.8 microFarad, 10 microFarad, 100V	6
11.	Potentiometer	100kohm	1-18
12.	Incandescent lamp	60 Watt	
13.	Digital Multimeter	4 1/2-digit, 19999 count TRMS	1-18
14.	True RMS multi-meter	1.0% + 3 (DC, 45 Hz to 500 Hz) 2.0% + 3 (500 Hz to 1 kHz)	1-18
15.	Dual channel CRO	25 MHZ with isolation Transformer or power scope, attenuator probe for CRO	1-18
16.	DC Regulated Power Supply	0-30 V,0-2 A,0-300 V,0-10 A	1-18
17.	Single phase AC supply	230V,10 A	1-18
18.	Experimental Thyristorised Kits	Choppers, Inverters, Dual Converters, Cycloconverter, Induction heating, Dielectric heating and connecting cords.	8-15
19.	Resistive load	Lamp-100W, Heater Coil-500W	8,9,12
20.	Resistive- inductive load	(Single phase fractional 1/4 HP,60W/75W Motor) as per requirement of the load	8,9,13
21.	Bread Board		1-18
22.	Open Source software	Free/License version	1-18

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Power Electronics	Bimbhra, P.S	Khanna Publication, 5th Edition, 2012 ISBN: 978-8174092793
2.	Power Electronics Circuit Devices and application	Rashid, Muhammad H.	Pearson Education India 4th Edition, 2020 ISBN: 9789332584587, 9789332584587
3.	Power Electronics Handbook	Rashid, Muhammad H.	4th Edition - September 9, 2017 ISBN: 9780128114070 eBook ISBN: 9780128114087
4.	Power Electronics	Ned Mohan, Tore M. undeland, William P Robbins	Wiley India Edition 3rd edition, 2010 ISBN: 9788126510900, 8126510900
5.	Modern Power Electronics	SEN, P.C	S. CHAND & CO. Ltd., ISBN: 9788121924252, 9788121924252
6.	Power Electronics	Singh M.D., Khanchandani K.B.	Mcgraw Hill Education 2nd edition, 2017 978-0070583894
7.	Fundamentals of Power Electronics	Bhattacharya, S. K.	Vikas publishing House 1st Edition,2009 ISBN: 978-8125918530
8.	Power Electronics	Chitode, J.S.	Technical Publications 1st edition, May 2008 ISBN: 978-8184314182
9.	Power Electronics	Gupta, B. R., Singhal V.	Katson Books 6th Edition, 2010 ISBN: 978-8185749532

(b) Online Educational Resources:

1. www.nptel.ac.in
2. www.en.wikibooks.org/wiki/power_electronics
3. www.books.google.co.in/books/about/power_electronics
4. Power electronics: http://nptel.ac.in/syllabus/108101038/
5. SCR: https://www.youtube.com/watch?v=CFonDZVRdAc
6. Cyclo-Converter: https://www.youtube.com/watch?v=FwtDWgKQaA4
7. Video lecturer: http://freevideolectures.com/Course/2351/Power-Electronics
8. https://www.tutorialspoint.com/power_electronics/index.htm
9. Online Magazine:http://www.powerelectronics.com/
10. Python Power electronics simulation software

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational resources before use by the students.

(c) Others:

1. Power Electronics Handbook edited by Rashid, Muhammad H.
2. Suppliers Manuals of various devices
3. Manufacturers' operating Manual

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A) Course Code : **2420402(T2420402/P2420402/S2420402)**

B) Course Title : Microprocessor and Microcontroller

C) Pre-requisite Course(s) : Fundamentals of Electronics Engineering

D) Rationale:

Microprocessor and Microcontroller as a course is at the core of automation in industrial, domestic, consumer goods and other high-end products. Diploma engineers have to understand and apply the concepts of various microprocessor and microcontroller-based systems and maintain them. This course is meant to provide the basic and holistic approach and develop skills to electrical diploma holders for solving the microprocessor and microcontroller-based application problems related to automation systems.

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 Analyze the architecture of Microprocessor IC 8085.

CO-2 Develop the assembly language programs for various operations using instruction set of 8085 Microprocessor.

CO-3 Interface the memory and I/O devices to 8085 Microprocessor.

CO-4 Analyze the architecture of Microcontroller IC 8051.

CO-5 Develop the assembly language programs for various operations using instruction set of 8051 Microcontroller.

F) Suggested Course Articulation Matrix (CAM):

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

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

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional.

G) Teaching & Learning Scheme:

Board of Study	Course Code	Course Title	Teaching & Learning Scheme (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	**T**				
Electronics Engineering	**2420402**	Microprocessor and Microcontroller	03	-	04	02	09	06

Legend:

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

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

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

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

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

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

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

H) Assessment Scheme:

Board of Study	Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment (TA)		Term Work & Self Learning Assessment (TWA)		Lab Assessment (LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
Electrical Engineering	**2420402**	Microprocessor and Microcontroller	30	70	20	30	20	30	200

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self-Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

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

J) Theory Session Outcomes (TSOs) and Units: T2420402

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Interpret the general-purpose microprocessor. *TSO 1b.* Explain the architecture of 8085 microprocessor with block diagram. *TSO 1c.* Explain various types of interrupts.	**Unit-1.0 Microprocessor 8085** 1.1 Evolution of Microprocessors 1.2 Architecture and Pin Diagram of 8085 1.3 Timing Diagram 1.4 Memory Organization 1.5 Interrupts	**CO1**
TSO 2a. Classify the different types of instruction used in 8085. *TSO 2b.* Differentiate addressing modes of 8085 microprocessor. *TSO 2c.* Differentiate addressing modes of 8085 microprocessor. *TSO 2d.* Use various types of instruction to write ALP.	**Unit-2.0 Instruction Set and Assembly Language Programming Of 8085 Microprocessor** 2.1 Instruction Set: • Data transfer instructions • Control instructions • Arithmetic instructions • Logical instructions • Branching instructions 2.2 Different types of addressing modes: • Immediate addressing mode • Register addressing mode • Direct addressing mode • Indirect addressing mode • Indexed addressing mode 2.3 Assembly Language Programming	**CO1, CO2**
TSO 3a. Interface Intel PPI 8255 with 8085. *TSO 3b.* Interface various memory chips with 8085 microprocessors. *TSO 3c.* Explain the operation of interfacing chips. *TSO 3d.* Differentiate between the serial and parallel communication modes of 8085 microprocessor.	**Unit-3.0 Interfacing with 8085 Microprocessor:** 3.1 Programmable Peripheral Interface (PPI) IC -Intel 8255 (Generation of I/O Ports) 3.2 Programmable Interval Timer ICs (Intel 8253/8254) 3.3 Overview of memory chips and their interfaces 3.4 Overview of other interfacing chips (Name and Application(s) only)	**CO1, CO3**
TSO 4a. Explain the architecture of 8051 microcontroller with block diagram representation. *TSO 4b.* Describe special function registers. *TSO 4c.* Explain the memory and I/O interfacing of 8051 microcontroller *TSO 4d.* Explain various types of operands with addressing.	**Unit-4.0 Overview of Microcontroller 8051:** 4.1 Comparison of Microprocessors and Microcontrollers 4.2 Architecture of 8051 Microcontroller 4.3 Memory organization 4.4 Special Function Registers (SFRs) 4.5 Port Operation 4.6 Memory Interfacing 4.7 I/O Interfacing 4.8 Programming 8051 resources, interrupts 4.9 Programmer's model of 8051 4.10 Operand types, Operand addressing	**CO4**
TSO 5a. Difference between high level language and low-level language. *TSO 5b.* Select structure of assembly language. *TSO 5c.* Explain the different microcontroller developing tools. *TSO 5d.* Explain different assembler directives. *TSO 5e.* Develop simple programmes using 8051 instructions.	**Unit 5 Programing with 8051** 5.1 Instruction set 5.2 Data transfer instructions 5.3 Arithmetic instructions 5.4 Logic instructions 5.5 Control transfer instructions 5.6 Boolean instructions 5.7 Timer & counter programming 5.8 Interrupt programming	**CO4, CO5**

Note: One major TSO may require more than one theory session/period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2420402

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1. Examine the 8085 Trainer Kit. *LSO 1.2.* Identify the various components in *8085* Trainer Kit.	1.	Test and verify the features of 8085 Trainer Kit.	CO1, CO2
LSO 2.1. Write an assembly language program based on data transfer instructions and arithmetic instructions. *LSO 2.2.* Test the results by assembly language program.	2.	Write and execute an ALP for 8085 to add two 8-bit Nos. which is stored at two different memory locations and store the result (with carry & without carry cases) at another memory locations.	CO1, CO2
LSO 3.1. Write an assembly language program based on data transfer instructions and arithmetic instructions. *LSO 3.2.* Test the results by executing assembly language program.	3.	Write and execute an ALP for 8085 to subtract two 8-bit nos. which is stored at two different memory locations and store the result (with carry & without carry cases) at another memory locations.	CO1, CO2
LSO 4.1. Write an assembly language program based on arithmetic instructions to find smallest and largest numbers. *LSO 4.2.* Test the results by executing assembly language program.	4	Write an assembly language program for finding largest / smallest number	CO1, CO2
LSO 5.1. Write an assembly language program for arranging numbers in ascending/descending order. *LSO 5.2.* Test the results by executing assembly language program.	5	Write an assembly language program for arranging numbers in ascending/descending order.	CO1, CO2
LSO 6.1. Develop an assembly language program to interface 8255 IC with 8051 Microcontroller. *LSO 6.2.* Test the results using an assembly language program.	6.	Interface 8255 IC with the 8085 microprocessors to perform given input/output operations.	CO3, CO1
LSO 7.1. Examine the 8051 Trainer kit. *LSO 7.2.* Identify the various components in 8051 Trainer Kit.	7.	Test and verify the features of 8051 Trainer Kit	CO4
LSO 8.1. Write an assembly language program based on Data transfer Instructions & Arithmetic Instructions. *LSO 8.2.* Test the results by executing assembly language program.	8.	Write and execute an ALP for 8051 to add two 8-bit Nos. which is stored at two different memory locations and store the result (with carry & without carry cases) at another memory locations.	CO4, CO5
LSO 9.1. Write an assembly language program based on Data transfer Instructions & Arithmetic Instructions. *LSO 9.2.* Test the results by executing assembly language program.	9.	Write and execute an ALP for 8051 to Subtract two 8-bit Nos. which is stored at two different memory locations and store the result (with carry & without carry cases) at another memory locations.	CO4, CO5
LSO 10.1. Develop an assembly language program to generate delay using timer in 8051 Microcontroller. *LSO 10.2.* Test the results by executing assembly language program.	10.	Write an ALP to generate delay, using Timer.	CO4, CO5
LSO 11.1. Develop an assembly language program to interface 7 segment display with 8051 Microcontroller.	11.	Develop a program to interface 7 segment display with 8051.	CO4, CO5

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 11.2. Test the results using an assembly language program.			
LSO 12.1. Test the result using an assembly language program to interface DC Motor with 8051.	12.	Interface a DC Motor with 8051.	CO4, CO5
LSO 13.1. Test the results by executing an assembly language program to interface Stepper Motor with 8051.	13.	Develop a program to interface a Stepper Motor with 8051.	CO4, CO5

L) Suggested Term Work and Self Learning: S2420402 Some sample suggested micro projects and other activities are mentioned here for reference.

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

b. Micro Projects

1. Automatic Night Lamp with Morning Alarm using Microprocessor
2. Design of a Microprocessor based Automatic Gate.
3. Microcontroller based line follower robot.
4. Android controlled 2 axes pick and place robot.
5. Home appliances controlling using android mobile via Bluetooth.
6. Android based ultrasonic distance meter with buzzer indication.
7. Speed control of dc motor using android mobile.
8. Microcontroller based Solar Charger

c. Other Activities:

1. Seminar Topics:
   - Li-fi Data Transfer System.
   - IOT Based Person/Wheelchair Fall Detection.
   - IOT based Smart Energy Meter Monitoring with Theft Detection.
   - Health Monitoring System using 7-Segment Display & Atmega Microcontroller.
   - Microcontroller based data acquisition system for renewable energy sources
2. Visits: Visit nearby tool room/industry with proper facilities. Prepare report of visit with special comments of network theorems used, transient and steady state response, resonance behavior and safety procedure.
   - TRTC (Tool Room and Training Center)
   - Automatic vehicle industry
3. Self-learning topics:
   - ATMEL
   - Atmega Microcontroller
   - Virtual Lab on microcontroller-based simulation of problems.

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

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self-Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	25%	20%	15%	20%	20%	10%	20%
CO-2	20%	20%	10%	20%	20%	30%	20%
CO-3	15%	10%	15%	20%	20%	10%	20%
CO-4	30%	30%	30%	20%	20%	20%	20%
CO-5	20%	30%	30%	20%	20%	30%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

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

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Microprocessor 8085	8	CO1	14	4	6	4
Unit-2.0 Instruction Set and Addressing Language Programming of 8085	12	CO1, CO2	14	4	4	6
Unit-3.0 Interfacing with 8085 Microprocessor	8	CO1, CO3	10	2	4	4
Unit-4.0 Overview of Microcontroller 8051	10	CO4	16	6	6	4
Unit 5.0 Programing with 8051	10	CO4, CO5	16	4	6	6
Total	**48**	**-**	**70**	**20**	**26**	**24**

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number (s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Test and verify the features of 8085 Trainer Kit.	CO1, CO2	30	60	10
2.	Write and execute an ALP for 8085 to add two 8-bit Nos. which is stored at two different memory locations and store the result (with carry & without carry cases) at another memory locations.	CO1, CO2	40	50	10
3.	Write and execute an ALP for 8085 to Subtract two 8-bit Nos. which is stored at two different memory locations and store the result (with carry & without carry cases) at another memory locations.	CO1, CO2	30	60	10
4.	Write an assembly language program for finding largest / smallest number.	CO1, CO2	30	60	10
5.	Write an assembly language program for arranging numbers in ascending/descending order.	CO1, CO2	40	50	10
6.	Interface 8255 IC with the 8085 microprocessors to perform given input/output operations.	CO3, CO1	40	50	10
7.	Test and verify the features of 8051 Trainer Kit.	CO4	30	60	10
8.	Write and execute an ALP for 8051 to add two 8-bit Nos. which is stored at two different memory locations and store the result (with carry & without carry cases) at another memory locations.	CO4, CO5	30	60	10
9.	Write and execute an ALP for 8051 to Subtract two 8-bit Nos. which is stored at two different memory locations and store the result (with carry & without carry cases) at another memory locations.	CO4, CO5	30	60	10
10.	Write an ALP to generate delay, using Timer.	CO4, CO5	30	60	10
11.	Develop a program to interface 7 segment display with 8051.	CO4, CO5	40	50	10
12.	Develop a program to interface a DC Motor with 8051.	CO4, CO5	40	50	10
13.	Develop a program to interface a Stepper Motor with 8051.	CO4, CO5	40	50	10

PRA*: Process Assessment
PDA**: Product Assessment

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

P) Suggested Instructional/Implementation Strategies: Different Instructional/ ImplementationStrategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, 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.	Microprocessor Trainer kit	Single board systems with 8K RAM, ROM memory with battery backup, 16X4,16 X2, LCD display, PC keyboard interfacing facility, Hex keypad facility, single user cross c-compiler, RS- 232, USB, interfacing facility with built in power supply.	1 to 5
2.	Microcontroller Trainer kit	Single board systems with 8K RAM, ROM memory with battery backup, 16X4,16X2, LCD display, PC keyboard interfacing facility, Hex keypad facility, single user cross c-compiler, RS- 232, USB, interfacing facility with built in power supply.	6 to 12
3.	PC	Desktop PC with microcontroller simulation software	All
4.	CRO	Bandwidth AC l0Hz~20MHz(-3dB), DC~ 20MHz (-3dB), Xl0 Probe	All
5.	Trainer Kit for Stepper Motor	Stepper Motor :50/100 RPM	12
6.	Trainer Kit	Trainer Kit for DC motor	11
7.	7-segment LED Display	7-segment LED Display: -0.56 in 1-digit, common anode/common cathode	10

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	8085 Microprocessor	Ramesh S. Gaonkar	Prentice Hall, 5th Edition, ISBN: 0130195707
2.	Fundamentals of Microprocessor & Microcontroller	B.Ram	Dhanpat Rai & Sons Pub., 3rd edition, 2008, ISBN: 978-8189928605
3.	8051 Microcontroller Architecture, Programming and Applications	Kenneth J. Ayala	EEE/Prentice Hall of India,2nd edition, New Delhi, 2004, ISBN: 978-1401861582
4.	The 8051 Microcontroller and Embedded system	Mohmad Ali Mazidi, Janice Gelispe Mazidi, Roline D. McKinley	Pearson/Prentice Hall,2nd edition, Delhi,2008, ISBN: 978-8177589030
5.	Microcontroller Principle and Applications	Ajit Pal	Prentice Hall, India, New Delhi, 2014, ISBN: 978-8120343924
6.	Microcontroller Theory and Applications	Ajay Deshmukh	Tata McGraw Hill Pvt. Ltd., New Delhi, 2011, ISBN: 978-0070585959
7.	Microcontroller Architecture Programming, Interfacing and System Design	Raj Kamal	Pearson Education India, Delhi, 2012, ISBN:978-8131759905

(b) Online Educational Resources:

1. https://nptel.ac.in/courses/117104072
2. Simulation software: -www.keil.com.
3. https://archive.nptel.ac.in/courses/108/105/108105102/
4. https://nptel.ac.in/courses/108105102

5. https://www.britannica.com/technology/microprocessor
6. Memory: www.slideshare.net/aismahesh/memory-8051
7. Microcontroller: www.binaryupdates.com/switch-with-8051-microcontroller/
8. Software: www.edsim51.com
9. Microcontroller project: www.8051projects.net/download-c4-8051-projects.html
10. https://fossee.in/
11. https://www.arduino.cc/en/hardware
12. https://www.mikroe.com/mikroc-pic
13. https://www.tinkercad.com/

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

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A) Course Code : **2420403(T2420403/P2420403/S2420403)**

B) Course Title : AC Machines

C) Pre- requisite Course(s) : Basic Electrical Engineering, DC Machines and Transformer, Electrical measurements and Instrumentation

D) Rationale :

Electrical Engineering diploma holders are expected to apply the principle of electromechanical energy conversion in operating, testing and troubleshooting different types of AC machines including special machines. This course will enable them to develop a set of knowledge, skills and attitude for maintaining 3 phase and single-phase induction motor, Synchronous machines and special electrical machines taking appropriate safety measures. This course fundamentally aims at familiarizing the students with the fundamentals of various AC machines and special electrical machines and their applications. This is also a prerequisite course for mastering in Electrical drives.

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** Maintain three phase Induction Motor.
- **CO-2** Use relevant Single-phase Induction Motors for various applications.
- **CO-3** Synchronize an alternator with bus bar/another alternator.
- **CO-4** Use synchronous motors for industrial applications.
- **CO-5** Use special electrical machines for different applications.

F) Suggested Course Articulation Matrix (CAM):

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

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

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Board of Study	Course Code	Course Title	Scheme of Study (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
Electrical Engineering	**2420403**	AC Machines	03	-	04	02	09	06

Legend:

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

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

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

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

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

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

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

H) Assessment Scheme:

Board of Study	Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
Electrical Engineering	**2420403**	AC Machines	30	70	20	30	20	30	200

Legend:

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

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

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

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

J) Theory Session Outcomes (TSOs) and Units: T2420403

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Describe the constructional details of three phase induction motor. TSO 1b. Explain the working principle of the given Induction motor TSO 1c. Classify the Induction machine on the basis of rotor. TSO 1d. Interpret torque slip characteristics of the given three phase induction motor. TSO 1e. Justify the need of different types of starters used in Induction motor TSO 1f. Describe the procedure to control the speed of the given Induction motor. TSO 1g. Describe the maintenance procedure of the given 3 phase induction motor. TSO 1h. Describe the Selection procedure of three phase induction motor for the given applications.	**Unit-1.0 Three Phase Induction Motor** 1.1 Construction and working principle 1.2 Slip and slip speed 1.3 Types-Squirrel cage and Slip ring Induction motors 1.4 Equivalent circuit and phasor diagram 1.5 Torque equation, Starting, running and condition for the maximum torque (Only expression) 1.6 Starter and its necessary 1.7 Types of starters- DOL, Star Delta, Autotransformer and rotor resistance starter 1.8 No load and Blocked rotor test, Losses and efficiency 1.9 Speed control of squirrel cage and slip-ring induction motor: stator voltage, pole changing, rotor resistance and Variable Voltage and Variable Frequency (VVVF) 1.10 Maintenance procedure, Rewinding of three phase induction motor 1.11 Motors selection for different applications as per the load torque speed requirements	**CO1**
TSO 2a. Explain the construction and working principle of a single-phase induction motor. *TSO 2b.* Classify the single-phase induction motor based on different starting methods. *TSO 2c.* Interpret the speed torque characteristics of the given single-phase induction motor. *TSO 2d.* Describe the selection procedure of single-phase Induction motors for the given application. *TSO 2e.* Describe the general maintenance procedure of the given single-phase induction motor.	**Unit-2.0 Single Phase Induction Motor** 2.1 Construction and Principle of operation: Double revolving field theory. 2.2 Equivalent circuit. 2.3 Starting of Single-phase Induction Motor: Split phase- Resistance start, capacitor start, capacitor start capacitor run and shaded pole Induction motor with their torque speed characteristics 2.4 Applications of various types of single-phase induction motor. 2.5 Maintenance of different types of single-phase motors, rewinding.	**CO1, CO2**
TSO 3a. Explain the constructional details of a synchronous machine with a neat sketch. TSO 3b. Explain the working principle of an alternator. TSO 3c. Differentiate between turbo and hydro generators. TSO 3d. Describe the effect of armature reaction at different excitation	**Unit-3.0 Alternators** 3.1 Construction- Salient and Cylindrical rotor. 3.2 Rotating magnetic field and working of Alternator (Synchronous generator), Synchronous speed and slip speed 3.3 Equivalent circuit model. 3.4 EMF equation 3.5 Chording factor, breadth factor	**CO3, CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 3e. Determine voltage regulation of the given alternator by synchronous impedance method. TSO 3f. Interpret the power-angle characteristics of an alternator TSO 3g. Synchronize the given alternator with infinite bus bar or another alternator. TSO 3h. Explain the essential conditions for the parallel operation of two alternators.	3.6 Nature of armature reaction at unity power factor, lagging and leading pf. 3.7 Open circuit and short circuit characteristics. 3.8 Voltage regulation-voltage regulation by synchronous impedance method. 3.9 Operating characteristics- Power angle characteristics, effect of excitation on variable load 3.10 Synchronization and conditions of synchronization. 3.11 Synchronization of alternator with bus bar/alternator- two bright and one dark lamp method, synchroscope method 3.12 Parallel operation of alternators.	
TSO 4a. Explain the working principle of synchronous motor. TSO 4b. Describe the given method(s) of starting of a synchronous motor. TSO 4c. Explain the significance of V and inverted V curves. TSO 4d. Interpret the effect of change in excitation in synchronous motor at constant load. TSO 4e. Explain the phenomenon of hunting in synchronous machine. TSO 4f. Describe the industrial applications of synchronous motor.	**Unit-4.0 Synchronous Motor** 4.1 Working principle, Starting of Synchronous motor. 4.2 Equivalent circuit, Phasor diagram. 4.3 Power angle characteristics. 4.4 Effect of change in excitation at constant load, 'V' and inverted 'V' curves. 4.5 Hunting and its prevention. 4.6 Applications of synchronous motor- synchronous phase modifier, constant speed drives.	**CO3, CO4**
TSO 5a. Explain the construction and working of the given special electrical machine with the help of a neat labelled sketch. TSO 5b. Interpret the speed torque characteristics of the given special motor. TSO 5c. Describe the select procedure of special machine for the given application.	**Unit-5.0 Special Electrical Machines** 5.1 Construction, working and speed-torque characteristics and applications of – **[i]** AC servo motor **[ii]** Stepper motor **[iii]** Linear Induction Motor (LIM) **[iv]** Reluctance motor **[v]** Hysteresis motor [vi] Universal motor 5.2 Criteria for the selection of special motor	**CO4, CO5**

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2420403

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1. Identify different parts of a cut section model of the given three phase Induction motor.	1.	Assemble/ Disassemble a cut section model of a given 3 phase Induction motor and identify its parts	CO1
LSO 1.2. Measure slip of the given Induction motor by using tachometer and stroboscopic method.	2.	Slip measurement of a 3-phase Induction motor by using: (i) Tachometer and (ii) Stroboscopic method.	CO1
LSO 1.3. Test the performance of three phase induction motor.	3.	Direct load test on three phase induction motor and draw performance characteristics.	CO1
LSO 1.4. Start a given three phase induction motor using DOL, star delta and auto transformer starter.	4.	Starting of three phase induction motor using starters.	CO1
LSO 1.5. Control the speed of squirrel cage Induction motor by changing supply voltage *LSO 1.6.* Control the speed of squirrel cage Induction motor by changing frequency	5.	Speed control of squirrel cage induction motor.	CO1
LSO 1.7. Control the speed of slip ring induction motor by using rotor rheostat.	6.	Speed control of slip-ring induction motor.	CO1
LSO 1.8. Analyze the performance of given three phase Induction motor.	7.	No load and blocked rotor test of a 3-phase induction motor	CO1
LSO 2.1. Test the performance of a ceiling fan motor.	8.	Testing of ceiling fan motor.	CO2
LSO 2.2. Measure rotational losses of the given single-phase induction motor using no load test method.	9.	No load test on a single-phase induction motor to measure rotational losses.	CO2
LSO 2.3. Test the performance of single-phase capacitor type induction motor.	10.	Load test on single phase capacitor type induction motor	CO2
LSO 3.1. Test the performance of an alternator by direct load test method to determine the voltage regulation.	11.	Load test on alternator to determine voltage regulation.	CO3
LSO 3.2. Perform Open Circuit (OC) and Short Circuit (SC) test on a single-phase alternator to determine the voltage regulation at unity, lag and lead pf.	12.	Open circuit and short circuit test on a single-phase alternator	CO3
LSO 3.3. Synchronize the given alternator with infinite bus bar by using two bright and one dark lamp method. *LSO 3.4.* Synchronize the given alternator with infinite bus bar by using Synchroscope method.	13.	Synchronization of alternator with infinite bus bar- [i] By two bright and one dark lamp Method [ii] By Synchroscope	CO3
LSO 4.1. Test the performance of given synchronous motor at different load conditions *LSO 4.2.* Analyze V and Inverted V curve for the given synchronous motor.	14.	Performance of synchronous motor at different load conditions to see the effect of variation ofexcitation and pf (V & inverted V curve)	CO3, CO4, CO5
LSO 5.1. Test the performance of AC servo motor.	15.	Testing of AC servo motor.	CO5

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 5.1. Test the performance of Linear Induction motor.	16.	Demonstrate the working of a Linear Induction Motor.	CO1, CO2, CO5
LSO 5.2. Test the performance of stepper motor.	17.	Demonstrate the working of a Stepper Motor.	CO5
LSO 5.3. Test the performance of hysteresis motor.	18.	Demonstrate the working of a Hysteresis Motor.	CO4, CO5
LSO 5.4. Test the performance of reluctance motor.	19.	Demonstrate the working of a reluctance Motor.	CO4, CO5
LSO 5.5. Demonstrate the working of a Universal motor.	20.	Demonstrate the working of a Universal Motor.	CO5

L) Suggested Term Work and Self Learning: S2420403 Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

1. State the commercial and industrial applications of 3 phase squirrel cage and slip ring induction motors.
2. Prepare the report on salient features of starters used to start the 3-phase induction motor
3. Explain why single-phase induction motors are not self-starting.
4. Justify the need of auxiliary winding in single phase induction motor.
5. List the applications of following motors;
   Split phase motor (b) capacitor start motor (c) shaded pole motor
7. Justify the use of alternator over other generators for the generation of electricity.

b. Micro Projects:

1. Prepare a working model of a Linear Induction Motor (LIM) using available materials.
2. Prepare a report on full step and half step stepper motors including calculation of step angle.
3. Dismantle the given semi-automatic washing machine and identify each component and its functionality. Also prepare report of it mentioning the standard procedure of dismantling and assembling the same.
4. Dismantle the given mixer grinder and identify each component and its functionality. Also prepare report of it mentioning the standard procedure of dismantling and assembling the same.
5. Dismantle the motor in an electrically operated sewing machine and identify each components and its functionality. Also prepare report of it mentioning the standard procedure of dismantling and assembling the same.

c. Other Activities:

1. Seminar Topics:
   - Use of induction motors for various applications.
   - Different types of starters used in Induction motors.
   - Starting of synchronous motors.
   - Different types of excitation systems used for the field winding of an alternator.

2. Visits:
   - Visit nearby thermal power plant. Prepare a report on various AC machines (Synchronous machines and Induction motors) used in different sections of the power plant.
   - Visit a nearby equipment supplier and collect the specification of various special electrical machines available in the market for different applications.

3. Self-learning topics:
   - Soft starter used for induction motors.
   - Induction generator
   - Inverted Induction motor
   - Blondel's two reaction theory
   - Hunting in Synchronous motor
   - Cooling systems used in alternators
   - Elimination of harmonics in alternators.

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

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	25%	25%	25%	100%	30%	35%	20%
CO-2	15%	15%	15%		10%	15%	20%
CO-3	25%	25%	25%		30%	15%	20%
CO-4	20%	20%	20%		10%	15%	20%
CO-5	15%	15%	15%		10%	20%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

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

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) **Suggested Specification Table for End Semester Theory Assessment:** Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (Cl) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Three Phase Induction Motor	8	CO1	18	5	6	7
Unit-2.0 Single Phase Induction Motor	8	CO1, CO2	12	4	3	5
Unit-3.0 Alternators	8	CO3, CO4	18	5	6	7
Unit-4.0 Synchronous Motor	12	CO3, CO4	12	4	4	4
Unit-5.0 3D Special Electrical Machines	12	CO2, CO4, CO5	10	2	2	6
Total	**48**	**-**	**70**	**20**	**21**	**29**

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Assemble/ Disassemble a cut section model of a given 3 phase Induction motor and identify its parts	CO1	60	30	10
2.	Slip measurement of a 3-phase Induction motor by using: (iii) Tachometer and (iv) Stroboscopic method.	CO1	50	40	10
3.	Direct load test on three phase induction motor and draw performance characteristics.	CO1	50	40	10
4.	Starting of three phase induction motor using starters.	CO1	60	30	10
5.	Speed control test of squirrel cage induction motor.	CO1	60	30	10
6.	Speed control of slip-ring induction motor.	CO1	50	40	10
7.	No load and blocked rotor test of a 3-phase induction motor.	CO1	50	40	10
8.	Testing of ceiling fan motor.	CO2	60	30	10
9.	No load test on a single-phase induction motor to measure rotational losses.	CO2	50	40	10
10.	Load test on single phase capacitor type induction motor	CO2	60	30	10
11.	Load test on alternator to determine voltage regulation.	CO3	50	40	10
12.	Open circuit and short circuit test on a single-phase alternator	CO3	50	40	10
13.	Synchronization of alternator with infinite bus bar- [iii] By two bright and one dark lamp Method [iv] By Synchroscope	CO3	50	40	10
14.	Performance of synchronous motor at different load conditions to see the effect of variation ofexcitation and pf (V & inverted V curve)	CO4	50	40	10
15.	Testing of AC servo motor.	CO5	50	40	10
16.	Demonstrate the working of a Linear Induction Motor.	CO5	50	40	10
17.	Demonstrate the working of a Stepper Motor.	CO5	50	40	10
18.	Demonstrate the working of a Hysteresis Motor.	CO5	50	40	10
19.	Demonstrate the working of a reluctance Motor.	CO5	50	40	10
20.	Demonstrate the working of a Universal Motor.	CO5	50	40	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	AC Ammeter	Range (0-5-10-20A), Portable analog MI type as per relevant BIS standard	All
2.	AC Voltmeter	Range (0-75/150/300V), Portable analog MI type as per relevant BIS standard	1,2
3.	AC Voltmeter	Range (0-150/300/600V), Portable analog MI type as per relevant BIS standard	
4.	Watt meter	0-2.5/5 A, 0-75/150/300V Portable Wattmeter	8, 9,10
5.	Wattmeter	0-5/10/20 A, 0-150/300/600V Portable Wattmeter	3,7,10
6.	Single phase autotransformer	0-230V/0-260V, 4/8A autotransformer	8,9,10
7.	3 phase Autotransformers	10 KVA, Input: 415V, Output 0-470V	6, 7, 8, 10
8.	Three phase variable Lamp load	10-20 A, 0-10kW	3,4
9.	Three phase variable inductive load	0-10 Amp	6, 7, 8, 10
10.	Rheostat	(0-500 Ohm, 1.2A); (0-100 Ohm, 5A); (0-50 Ohm, 10A); (0-350 Ohm,1.5A); Nichrome wire wound rheostat on epoxy resin or class F insulating tube with two fixed and one sliding contact	10
11.	Three phase induction motor	Cut section model	1
12.	Three phase induction motor with loading arrangement	5 HP, 440V, 8.0A, 1400 RPM Squirrel cage type with brake drum arrangement	1 to 5
13.	Three phase slip ring induction motor with external resistor bank	5 HP, 415V	6
14.	DOL Starter Star Delta Starter Autotransformer starter	-	4
15.	Synchronous motor	3 HP, 415V, 3-phase, 50Hz, 1500 RPM	14
16.	DC shunt motor -- Alternator set	5HP,220V, 1500 RPM, 18A, Excitation- 220V DC 3 HP, 415V, 3-phase, 50Hz, 1500 RPM	11,12,13
17.	Single phase induction motor	1 HP, 220 V, 50Hz, 1440 RPM Drum brake with spring balances	8,9,10

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
18.	AC Servomotor	-	15
19.	Universal motor	-	20
20.	Reluctance motor	-	19
21.	Hysteresis motor	-	18
22.	Linear Induction Motor	-	16
23.	Stepper Motor	-	17
24.	Tachometer	Contact type, Testing Range: 0.5 To 19999 RPM. Non-Contact type, Testing Range :2.5 to 99999 RPM (r/min).	

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Electrical Technology, Volume – II (AC & DC Machines)	Theraja B.L.	S. Chand and Co. Ltd., New Delhi ISBN:9788121924375
2.	Electrical Machinery	Dr. P.S. Bhimbra	Khanna Publications ISBN: 8174091734
3.	Basic Electrical Engineering	Mittle V.N. and Mittal Arvind	Tata McGraw Hill Education Pvt. Ltd. New Delhi ISBN:9780070593572
4.	Electrical Machines	Kothari, D.P. & Nagrath, I.J.	Tata McGraw Hill Education Pvt. Ltd. New Delhi,ISBN: 978007069967, 4th edition or latest, 2010
5.	Electrical Machines	Ashfaq Hussain	Dhanpat Rai & Company, ISBN: 6700000000432, Latest Edition
6.	Electrical Technology, Volume – II (AC & DC Machines)	Andreas Gebhardt,	Hanser Publisher, 2011 ISBN: 156990507X, 9781569905074
7.	Electrical Machines	Bhattacharya S. K.	Tata McGraw Hill Education Pvt. Ltd., NewDelhi ISBN:9789332902855
8.	Electrical Machines (AC & DC Machines	Gupta J. B.	S. K. Kataria& Sons, NewDelhi, ISBN:9788188458141
9.	Electrical Engineering Fundamentals	Vincent Del Toro	Prentice hall Publications ISBN-13 9780132475525
10.	Electric Machinery	Arthur Eugene Fitzgerald and Charles Kingsley	Tata McGraw Hill Education Publications ISBN13: 9780070530393
11.	Basic Electrical Engineering (Hindi)	Mehta & Gupta	Dhanpat Rai Publishing Company(P) Ltd., ISBN: 978938437826

(b) Online Educational Resources:

1. https://nptel.ac.in/courses/108105131
2. www.vlab.com/
3. https://www.youtube.com/watch?v=PmBqB-4hgW4&themeRefresh=1
4. https://www.youtube.com/watch?v=4texz0Gn7cw
5. www.youtube.com/watch?v=unxTKC01CBQ
6. https://www.youtube.com/watch?v=AQqyGNOP_3o
7. https://www.youtube.com/watch?v=oTSi27-FTNg
8. https://www.youtube.com/watch?v=O5P1aANy04o
9. https://www.youtube.com/watch?v=Ak6Zf-wJpsM
10. https://www.youtube.com/watch?v=5t1S8qy9oVk/

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

(c) Others:

1. Handbook of Electrical Machines by S.A. Nasar
2. Electrical engineering project guide
3. Electrical Machines Lab Manuals

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A) Course Code : **2420404 (T2420404/P2420404/S2420404)**

B) Course Title : Control System and PLC

C) Pre- requisite Course(s) : Basic engineering Mathematics, Fundamentals of Electronics Engineering

D) Rationale :

The modern industries are moving towards automation, wherein the various parameters such as position, speed is automatically Controlled and also at the same time the stability of the control system is also ensured. This is a branch of technology which applies automatic control theory to design various control systems in such a manner to achieve a desired control of operation of the system. The systems use mathematical modeling in terms of inputs and outputs to study the behaviors of systems. This course will facilitate the students to use different control strategies in various range of applications from simple home refrigeration systems to large industrial control systems. The course also introduces the control through P, PD, PI, PID controller as well as PLC which is widely used for automatically controlling the manufacturing process.

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

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

- **CO-1** Apply the basics of control system to a given system.
- **CO-2** Analyze time response of the first and second order control systems.
- **CO-3** Determine the stability of a given control system using Routh-Hurwitz and Bode plot methods.
- **CO-4** Use PID Controller to initiate control action in a given control system.
- **CO-5** Use PLC to control the simple industrial processes.

F) Suggested Course Articulation Matrix (CAM):

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

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

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Board of Study	Course Code	Course Title	Scheme of Study (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
Electrical Engineering	**2420404**	Automatic Control system and PLC	03	-	04	02	09	06

Legend:

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

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

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

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

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

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

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

H) Assessment Scheme:

Board of Study	Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
Electrical Engineering	**2420404**	Automatic Control system and PLC	30	70	20	30	20	30	200

Legend:

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

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

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

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

J) Theory Session Outcomes (TSOs) and Units: T2420404

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Classify the given type(s) of control system. *TSO 1b.* Draw block diagrams of different control systems and apply reduction techniques to reduce it. *TSO 1c.* Determine the transfer function of the given control system *TSO 1d.* Identify the poles and zeroes of given control system in s plane with justification. *TSO 1e.* Justify effect of feedback on control system	**Unit-1.0 Basics of Control System** 1.1 Control system -Open and closed loop, linear and nonlinear, time variant and time invariant 1.2 Feedback and its types- Degenerative and Regenerative, effect of feedback on stability and sensitivity. 1.3 Transfer function of R-C and R-L-C electrical circuits 1.4 Pole-Zero plot in S-plane 1.5 block diagram and its reduction techniques: Need and its Significance. 1.6 Control system components – Servomotors -AC and DC, Stepper motor, Error Detector-Potentiometer and Synchro, Feedback Element-Optical encoder -Incremental and absolute - Construction, working, speed torque characteristics and applications	**CO1**
TSO 2a. Explain transient and steady state time response of a given control system *TSO 2b.* Explain various standard test input signals step, ramp, parabolic and impulse signals applicable to a given control system. *TSO 2c.* Determine transfer function of a first order and second order system for a given input *TSO 2d.* Analyze first and second order system time response with unit step input signal *TSO 2e.* Solve simple numericals based on first and second order system *TSO 2f.* Define different time response specifications	**Unit-2.0 Time Response Analysis** 2.1 Time Response: Transient and steady state response 2.2 Standard Test Inputs: step, ramp, parabolic and Impulse inputs and their Laplace Transform and their graphical representation 2.3 Order and type of system with standard equations and examples 2.4 First order control system: Analysis for unit step input, concept of time constant 2.5 Second order control system: Analysis for unit step input (derivation not required), concept, effect of damping 2.6 Time Response Specifications: Rise time, Delay time, Peak time, Settling time, Peak overshoot, steady state errors (no derivations) and simple numericals 2.7 Steady state analysis: Type 0,1,2 systems steady state error and Steady state error constants and simple numericals	**CO2**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 3a. Explain the conditions for the stability of a given control system. *TSO 3b.* Determine the stability of a given control system using Routh's stability criteria. *TSO 3c.* Analyze stability of system using Routh's stability criteria *TSO 3d.* Explain necessary and sufficient conditions for stability *TSO 3e.* Explain frequency response specifications of the given control system. *TSO 3f.* Determine the stability of the given control system using Bode plot.	**Unit-3.0 Stability Analysis** 3.1 Concept of stability, root locations in s-plane and analysis, Stable, unstable, critically and conditionally stable system, Absolute and relative stability 3.2 Routh's stability criterion**:** Steps and procedures to find stability by Routh's stability criteria, numerical problems 3.3 Routh - Hurwitz polynomials, Necessary and sufficient conditions for stability 3.4 Frequency Response Analysis method: Concept, Advantages and Disadvantages, Frequency response specifications. 3.5 Bode Plot: Need, Magnitude plot and phase angle plot, Bode plot for gain K, poles and zeros at origin, and 1st order system, 3.6 Analysis of stability from Bode plot using Gain margin and Phase margin	**CO3**
TSO 4a. Explain the given process control system with the help of a block diagram *TSO 4b.* Describe the discontinuous control actions used for controlling the given process control system with a neat sketch. *TSO 4c.* Describe the basic continuous control actions used for controlling the given process control system using neat sketch. *TSO 4d.* Describe the composite continuous control actions used for controlling the given process control system. *TSO 4e.* Identify relevant control action(s) for the given process control system with justification and neat sketches	**Unit-4.0 Process Controllers Dynamics** 4.1 Process Control System: Block diagram, functions of each block 4.2 Control Actions i. Discontinuous Mode: ON-OFF controllers equations and neutral zone ii. Continuous Mode: Proportional, Integral and Derivative Controllers- output equation, response and characteristics 4.3 Composite Controllers: PI, PD and PID Controllers- Operation, output equations, response graph, comparison and applications	**CO4**
TSO 5a. Describe the working of a simple given industrial automation system along with a block diagram. *TSO 5b.* Describe the working of each building block of a simple given PLC system using block diagram. *TSO 5c.* Describe the steps to interface the input analog and digital devices to given PLC. *TSO 5d.* Describe the steps to interface the output analog and digital devices to given PLC. *TSO 5e.* Describe the program scan cycle of a given PLC. *TSO 5f.* List the advantages and applications of a given PLC. *TSO 5g.* Explain the steps for PLC installation	**Unit-5.0 Basics of PLC** 5.1 Definition of industrial automation, block diagram, working of each building block 5.2 PLC- Definition**,** Block diagram Parts of PLC, Principles of Operation, functions of various blocks, 5.3 Input and output modules- : analog & digital, I/O Specifications 5.4 Classification (fixed and modular PLCs) 5.5 PLC Scan cycle and speed of execution 5.6 Advantages and applications of PLC 5.7 PLC installation	**CO5**

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2420404

Practical/Lab Session Outcomes (LSOs)		S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1.	Plot the speed torque characteristics of an DC Servo motor	1.	Speed -Torque characteristics of an DC servo motor	**CO1**
LSO 1.2.	Plot the speed Torque characteristics of a AC servo motor	2.	Speed Torque characteristics of an AC servo motor	**CO1**
LSO 1.3.	Perform test on AC servomotor to control the position	3.	AC Position Control system	**CO1**
LSO 1.4.	Perform test on DC servo motor to control the position without and with feedback (Both Degenerative and regenerative)	4.	DC Position Control system	**CO1**
LSO 1.5.	Perform test on a given Synchro (Selsyn) transmitter and receiver pair	5.	Synchro (Selsyn) transmitter and receiver pair	**CO1**
LSO 2.1.	Plot the transient response of an RC circuit (First order system) when subjected to unit a step input.	6.	Transient response of a first order system	**CO2**
LSO 2.2.	Plot the transient response of an RLC circuit (second order system) when subjected to unit a step input.	7.	Transient response of a second order system	**CO2**
LSO 2.3.	Plot the transient time response of a series RLC circuit (second order system) and determine the rime response specifications.	8.	Determination of transient time response specification of an RLC series circuit (second order system)	**CO2**
LSO 3.1.	Use open source software to analyze the given system characteristic equation to find the stability of the system	9.	Use open source software i.e. SCILAB to find the stability of the system	**CO3**
LSO 4.1.	Test the functionality of temperature control with ON-OFF controller.	10.	Temperature control of a system using ON-OFF controller	**CO4**
LSO 4.2.	Use PI controller to control temperature of the given process.	11.	Temperature control of a system using PI controller	**CO4**
LSO 4.3.	Use PD controller to control temperature of the given process	12.	Temperature control of a system using PD controller	**CO4**
LSO 4.4.	Use PID controller to control temperature of the given process	13.	Temperature control of a process using PID controller	**CO4**
LSO 5.1.	Identify different parts of a PLC and Input and Output devices	14.	Identification of Parts of a PLC and Input & Output devices of a PLC	**CO5**
LSO 5.2.	Install a given PLC using step by step procedure	15.	Installation of a given PLC using proper procedure	**CO5**

L) Suggested Term Work and Self Learning: S2420404 Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

1. Differentiate between Degerative and regenerative feedback system
2. Solve simple numericals to determine transient response specifications of a second order control system.

3. Solve simple numericals to determine stability of a given control system using Routh-Hurwitz and Bode plot methods
4. Differentiate between the different types of controllers used in a system.
5. Write the specifications of different types of PLCs

b. Micro Projects:

1. Download a video to demonstrate the difference between an open and closed loop system and submit report on it.
2. Make a prototype model to demonstrate a real time control system with feedback.
3. Prepare a report on representing a real time physical system in the form of a block diagram
4. Prepare a report to demonstrate the difference between undamped, underdamped, Critical damping and overdamping in a control system.
5. Prepare a chart to depict different types of stability of a control system
6. Prepare a working model of on-off control for controlling water level in a water tank with alarming signal.
7. Download videos on PID controller and its use in any industrial process and submit report on it.
8. Prepare a report on Input and Output modules/devices used to interface a given PLC and submit the same

c. Other Activities:

1. Seminar Topics:

   - Commercially available Controllers and their make
   - Commercially available PLCs and their make
   - Industrial applications of different types of controllers
   - Industrial applications of PLC

2. Visits: Visit a nearby industry to observe the working of PID controller and PLC and prepare a report of visit with special comments on the type of controller/PLC used, make, its use and cost.

3. Self-learning topics:

   - Time response of first order system using MATLAB/Scilab
   - Time response of second order system and determine various parameters using MATLAB/Scilab.
   - Unit step response of a given higher order stable system using MATLAB/Scillab.
   - Time response and measure various parameters for under damped, over damped and critically damped system using MATLAB/Scilab.
   - Time response characteristic of a closed loop system using PID controllers and compare the system performance with respect to open loop system.

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

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	15%	15%	15%	100%	20%	30%	20%
CO-2	20%	20%	20%		30%-	20%	20%
CO-3	20%	20%	20%		10%	10%	20%
CO-4	20%	20%	20%		20%	26%	20%

CO-5	25%	25%	25%		20%	14%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

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

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (Cl) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Basics of Control System	8	CO1	11	3	4	4
Unit-2.0 Time response analysis	12	CO2	14	4	4	6
Unit-3.0 Stability Analysis	10	CO3	14	4	6	4
Unit-4.0 Process Controller Dynamics	10	CO4	14	4	4	6
Unit-5.0 Basics of PLC	8	CO5	17	5	6	6
Total	**48**	**-**	**70**	**20**	**24**	**26**

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Speed -Torque characteristics of an Dc servo motor	CO1	50	40	10
2.	Speed Torque characteristics of an AC servo motor	CO1	50	40	10
3.	AC Position Control system	CO1	50	40	10
4.	DC Position Control system	CO1	50	40	10
5.	Synchro (Selsyn) transmitter and receiver pair	CO1	50	40	10
6.	Transient response of a first order system	CO2	50	40	10
7.	Transient response of a second order system	CO2	50	40	10

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
8.	Determination of transient time response specification of an RLC series circuit (second order system)	CO2	50	40	10
9.	Use open source software i.e. SCILAB to find the stability of the system	CO3	50	40	10
10.	Temperature control of a system using ON-OFF controller	CO4	50	40	10
11.	Temperature control of a system using PI controller	CO4	50	40	10
12.	Temperature control of a system using PD controller	CO4	50	40	10
13.	Temperature control of a process using PID controller	CO4	50	40	10
14.	Identification of Parts of a PLC and Input & Output devices of a PLC	CO5	50	40	10
15.	Installation of a given PLC using proper procedure	CO5	50	40	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	DC servo motor Speed-Torque characteristics kit	Laboratory experimentation kit of reputed make	1
2.	AC servo motor Speed-Torque characteristics kit	Laboratory experimentation kit of reputed make	2
3.	AC position control system kit	Laboratory experimentation kit of reputed make	3
4.	DC Position trainer kit	Laboratory experimentation kit of reputed make	4
5.	Synchro transmitter and receiver kit	Laboratory experimentation kit of reputed make	5
6.	Standard test signal generator	Laboratory experimentation kit of reputed make	6,7
7.	Tyoe 1 trainer kit	Laboratory experimentation kit of reputed make	6
8.	Type 2 trainer kit	Laboratory experimentation kit of reputed make	7,8

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	DC servo motor Speed-Torque characteristics kit	Laboratory experimentation kit of reputed make	1
2.	AC servo motor Speed-Torque characteristics kit	Laboratory experimentation kit of reputed make	2
3.	AC position control system kit	Laboratory experimentation kit of reputed make	3
4.	DC Position trainer kit	Laboratory experimentation kit of reputed make	4
5.	Synchro transmitter and receiver kit	Laboratory experimentation kit of reputed make	5
9.	Cathode Ray Oscilloscope	Dual Trace 50 MHz, Input impedance -1Mega ohm	7,8
10.	Digital Multimeter	3 ½ digital display, 9999 count digital multimeter measures: V_{ac}, V_{dc} (1000V max), A_{dc} , A_{ac} (10Amp max), Resistance (0-100M ohm), Capacitance and Temperature measurement	ALL
11.	Software	SCILAB, MATLAB/SIMULINK	ALL

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Linear Control Systems	B.S. Manke	Khanna Publishing House, Delhi, Latest edition, ISBN-10 : 9788174093103 ISBN-13 : 978-8174093103
2.	Automatic Control Systems	S. Hasan Saeed	S.K. Kataria & Sons, New delhi ISBN-10 : 8190691929 ISBN-13 : 978-8190691925
3.	Control System Engineering	J. J Nagrath, Gopal M.	New Academic Science Ltd ISBN-10 : 1781833079 ISBN-13 : 978-1781833070
4.	Modern Control Engineering	Ogata, K.	PHI, 5th Edition, New Delhi, 2010 ISBN: 978812034010
5.	Programmable Logic Controllers	Petruzella, F. D.	Tata-McGraw Hill, 3rd Edition, 2010 ISBN: 9780071067386
6.	Introduction to Programmable Logic Controllers	Gary Dunning	Delmar Cengage Learning; 3rd edition (16 December 2005) ISBN-10 : 1401884261 ISBN-13 : 978-1401884260

(b) Online Educational Resources:

1. https://www.scilab.org/scilab
2. www.nptel.ac.in/courses/101108056/23
3. www.nptel.ac.in/courses/108101037/3
4. www.nptel.ac.in/courses/108101037/14
5. www.nptel.ac.in/courses/108101037/46
6. www.nptel.ac.in/courses/108105062/12

7. www.nptel.ac.in/courses/108101037/20
8. www.nptel.ac.in/courses/108103008/12
9. www.nptelvideos.com/control_systems/
10. www.electrical4u.com/control-engineering
11. www.automationfederation.org/filestore/af/resources/control
12. www.plcs.net

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

(c) Others:

1. The Control Handbook (three volume set) Edited by William S. Levine, CRC Press ISBN 9781420073669, 2011 Edition
2. Control system Users' Guide
3. Lab Manuals

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A) Course Code : **2420405 (P2420405/S2420405)**

B) Course Title : Electrical Software Lab

C) Pre- requisite Course(s) : Engg. Mathematics, Electrical Circuits and networks, Fundamentals of IT and C Programming

D) Rationale :

All electrical and electronic systems in industrial sector are designed based on drawings. Therefore, Electrical Drawing is used starting from designing, manufacturing, testing, till installation, commissioning and even for maintenance. A technician working in design and shop floor must possess skills of reading and interpreting of electrical engineering drawing. With the evolution of various computer software, the role of the earlier draftsman is now taken over by computer software. The AutoCAD software is widely used for drawing.

Due to revolution in ICT, the industries are switching to different Electronics Design and Automation (EDA)/ simulation tools to design, simulate various electrical/electronic circuits, test, analyze and interpret the results and graphs. Diploma pass outs are required to be competent in working with simulation tools particularly MATLAB/Simulink which not only provide facilities to choose amongst wide range of devices and components but also test and analyze the performance of an Electrical/Electronic circuit prior to its physical implementation thus reducing the cost, time and damage for hardware implementation by optimizing the circuit performance. Because of this the task of professionals in designing and analyzing circuits has become comparatively stress free. Hence this course is designed in such a way that the practical experiences will enable the diploma student to become competent not only in using the AutoCAD software but also become competent in using MATLAB/Simulink to simulate electrical/electronic circuits.

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 in classroom/ laboratory/ workshop/ field/ industry.

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

- **CO-1** Use standard symbols and codes for representing electrical and electronic components.
- **CO-2** Use Auto CAD software for the 2D view of an electrical component.
- **CO-3** Perform various arithmetic operations and plot different types of plots using MATLAB.
- **CO-4** Interpret the results of various electric and electronic circuits developed using MATLAB.
- **CO-5** Interpret the simulated model of electrical/electronic circuits developed using Simulink.

F) Suggested Course Articulation Matrix (CAM):

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

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

* PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Board of Study	Course Code	Course Title	Scheme of Study (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
Electrical Engineering	**2420405**	Electrical software Lab	-	-	04	02	06	03

Legend:

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

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

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

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

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

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

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

H) Assessment Scheme:

Board of Study	Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
Electrical Engineering	**2420405**	Electrical Software Lab	-	-	20	30	20	30	100

Legend:

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

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

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

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

J) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1.a Identify the given types of electrical and electronic components based on symbols. TSO 1.b Draw free hand sketch for a given substation. TSO 1.c Draw the layout of the installation of electrical appliance and their wiring diagram for the given residential house. TSO 1.d Draw Electrical substation earthing layout as per IS standards.	**Unit-1.0 Symbols and Codes** 1.1 ISI Symbols in electrical engineering 1.2 Conventions for circuit and schematic representation of electrical and electronic components, instruments, and equipment 1.3 Substation layout with circuit breaker, on-load and off-load isolators, Buchholz's relay, and other protective devices of transformers 1.4 Plate and Pipe Earthing	**CO1**
TSO 2.a Prepare Computer-Aided Drawing using Auto CAD. TSO 2.b Prepare cross sectional view of a given electrical machine using Auto CAD. TSO 2.c Draw the orthogonal projection of the given type of insulators using Auto CAD.	**Unit-2.0 Computer Aided Electrical Drawing (CAD)** 2.1 Computer-Aided Drawing: Draw command, edit command, Coordinate entry, Osnap, Layers, Dimensioning, Text in a drawing, Ortho command, Zoom T command, and plot command 2.2 General electrical and electronic symbols, Layouts of domestic, commercial, and industrial wiring (2D only) 2.3 Cross-Sectional view of: • Fuse and cables (2D) • D.C. Motor and their parts • Single-phase Transformer • Power transformer • Induction Motor • Insulators, Circuit Breakers, Lightning arresters	**CO1, CO2**
TSO 3.a List the major components of MATLAB environment. TSO 3.b Explain with an example the basic arithmetic operations on matrices and Arrays. TSO 3.c Perform functions and operations using variables and arrays to learn about relational and logical operators. TSO 3.d Access different features such as creating M-File, save M-File of MATLAB.	**Unit-3.0 MATLAB Environment** 3.1 Introduction: Features, applications, and software versions 3.2 Getting started MATLAB: Using it as a calculator, creating variables, Overwriting variables, Error messages, and Making corrections 3.3 M-File Script; Examples, Script side-effects M-File Functions; Anatomy of a M-File function, Input and output arguments,	**CO3**

Major Theory Session Outcomes (TSOs)		Units	Relevant COs Number(s)
TSO 3.e	Perform basic operation on matrices such as addition, subtraction, multiplication with simple examples	3.4 Controlling the hierarchy of operations or precedence, Controlling the appearance of floating-point numbers, 3.5 Managing the Workspace 4.1 Matrices and Operators: Introduction, the Colon Operator, Accessing Parts of a Matrix, Combining and Transforming Matrices, Matrix Building, Input-output, Plotting, Debugging. 3.6 Functions: Introduction, Function I/O, Formal Definition of Functions, Subfunctions, Scope, Advantages of Functions, Scripts, and Problem Solving 3.7 Plotting: Creating simple plots, adding titles, axis labels, and annotations, Multiple data sets in one plot, specifying line styles and colors, Copy/Paste Figures, Saving Figures	
TSO 3.f	Use functions in MATLAB in different applications of mathematical operation.		
TSO 3.g	Describe the procedural steps to plot various graphs as per given condition.		
TSO 4.a	Perform functions and operations using variables and arrays to learn about relational and logical operators.	**Unit-4.0 MATLAB Programmer's Toolbox** 4.2 If-Statements, Relational and Logical Operators 4.3 Nested If-Statements 4.4 Variable Number of Function Arguments, Robustness 4.5 Persistent Variables 4.6 For-Loops, While - Loops 4.7 Break Statements, Logical Indexing 4.8 Data Types: Strings, Structs, Cells 4.9 Applications of MATLAB in • Electrical circuits and networks • Electrical Machine • Power system • Control system and • Power Electronics	**CO3, CO4**
TSO 4.b	Write MATLAB program using If statements.		
TSO 4.c	Write MATLAB program using For-loop statements.		
TSO 4.d	Write MATLAB program using For and While loop statements.		
TSO 4.e	Write MATLAB program to plot the various performance characteristics of for 3-phase Induction motor.		
TSO 4.f	Write MATLAB program to plot the various waveforms for power converters.		
TSO 4.g	Write MATLAB program to plot pole zero pattern for a given transfer function.		
TSO 4.h	Write a MATLAB program to determine fault current for a given power system network.		
TSO 5.a	Use Simulink to plot the transient analysis of RLC, RL and RC circuits for sinusoidal and step inputs.	**Unit-5.0 Simulink** 5.1 Getting Started with Simulink 5.2 Simulink Library Browser 5.3 Connections 5.4 Block Specification 5.5 Toolboxes 5.6 Building Systems 5.7 Applications of Simulink to • Electrical Circuits and networks • Electrical Machine • Power system • Control system and • Power Electronics	**CO4, CO5**
TSO 5.b	Use Simulink to verify Superposition theorem, Thevenin's theorem, Norton's theorem and Maximum power Transfer theorem, analyze and interpret the results		
TSO 5.c	Use Simulink to plot the various performance characteristics of for 3-phase Induction motor.		
TSO 5.d	Use Simulink to plot pole zero pattern for a given Transfer Function.		
TSO 5.e	Use Simulink to plot the various waveforms for power converters.		
TSO 5.f	Use Simulink to perform fault analysis for a given power system network.		

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2420405

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Draw the symbols and notation of electrical equipment and measuring instruments commonly used in lab conforming to IS standards.	1.	Symbols and notation of electrical equipment and measuring instruments commonly used in lab conforming to IS standards	CO1
LSO 1.2 Draw the layout of a typical classroom showing the location of fans, light fixtures, switch boards, distribution boards.	2.	Layout of a typical classroom showing the location of fans, light fixtures, switch boards, distribution boards	CO1
LSO 1.3 Draw the foundation plan as per dimensions for installation of an 11/0.415kV distribution transformer for rating above 500 kVA.	3.	Drawing of Foundation plan as per dimensions for installation of an 11/0.415kV distribution transformer for rating above 500 kVA.	CO1
LSO 1.4 Draw the plate & pipe earthing installation confirming to IS standards.	4.	Drawing of Plate and pipe earthing installation confirming to IS standards.	CO1
LSO 2.1 Use AutoCAD to draw the Electrical and Electronic symbols.	5.	Drawing Electrical and Electronic symbols in AutoCAD	CO2
LSO 2.2 Use AutoCAD to draw the electrical feeder layout of the college.	6.	Drawing of Electrical feeder layout of the college in AutoCAD	CO2
LSO 2.3 Use AutoCAD to draw the typical LT and HT cable trench details.	7.	Drawing of typical LT and HT cable trench details in AutoCAD	CO2
LSO 3.1 Write a MATLAB program to Perform basic operation on matrices such as addition, subtraction, multiplication.	8.	Basic operation on matrices; such as addition, subtraction, multiplication using MATLAB	CO3
LSO 3.2 Write a MATLAB program for generation of various signals such as unit impulse, unit step, square, saw tooth, triangular, sinusoidal, ramp etc.	9.	MATLAB program to Generate Various signals such as Unit impulse, unit step, square, saw tooth, triangular, sinusoidal, ramp etc.	CO3
LSO 3.3 Write a MATLAB program for Perform functions and operations using variables and arrays to learn about relational and logical operators.	10.	MATLAB program for Perform functions and operations using variables and arrays to learn about relational and logical operators	CO3
LSO 3.4 Write a MATLAB program for the operations on signals and sequences such as addition, multiplication, scaling, shifting, folding.	11.	MATLAB program for operations on signals and sequences such as addition, multiplication, scaling, shifting, folding.	CO3
LSO 3.5 Write MATLAB program to perform functions and operations using variables and arrays to learn about trigonometric and exponential manipulations.	12.	MATLAB program to perform functions and operations using variables and arrays to learn about trigonometric and exponential manipulations	CO3
LSO 3.6 Write MATLAB program to plot and label 2 dimensional functions like Sin(t), Cos(t), Tan(t) and Sec(t) etc., for a given duration.	13.	MATLAB program for plotting and labelling 2 dimensional functions like Sin(t), Cos(t), Tan(t) and Sec(t) etc., for a given duration	CO3
LSO 4.1 Write MATLAB program to Perform functions and operations using variables and arrays to learn about relational and logical operators.	14.	MATLAB program to Perform functions and operations using variables and arrays to learn about relational and logical operators	CO4

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 4.2 Write MATLAB program to plot pole zero pattern for a given transfer function.	15.	MATLAB program to plot pole zero pattern for a given transfer function	CO3, CO4, CO5
LSOs 5.1 Find out the node voltages and respective branch currents from the simulated circuit.	16.	Node and loop analysis of the given electrical network using Simulink	CO3, CO4, CO5
LSOs 5.2 Determine branch voltages and branch current of given electrical circuit using various network theorems.	17.	Application of network theorems such as Thevenin's, Norton's, Superposition etc. to electrical networks using Simulink	CO3, CO4, CO5
LSOs 5.3 Use MATLAB package to Locate zeroes and poles and plotting the pole-zero maps in S plane and for the given TF.	18.	Locate the zeros and poles and plotting the pole zero maps in s-plane and z-plane for the given transfer function using MATLAB/Simulink	CO3, CO4, CO5
LSOs 5.4 Simulate a series and parallel resonant circuit.	19.	Simulation of Series and Parallel resonant circuit using Simulink	CO3, CO4, CO5
LSOs 5.5 Plot various waveforms of half wave rectifier from simulated model.	20.	Simulation of Half Wave rectifier using Simulink	CO3, CO4, CO5
LSOs 5.6 Plot various waveforms of single-phase diode bridge rectifiers with filter for R and RL loads from simulated model.	21.	Simulation of single-phase diode bridge rectifiers with filter for R and RL loads using Simulink	CO3, CO4, CO5
LSOs 5.7 Plot various waveforms of half wave-controlled rectifier from simulated model.	22.	Simulation of a half wave-controlled rectifier using Simulink	CO3, CO4, CO5
LSOs 5.8 Plot various waveforms of a full wave-controlled rectifier from simulated model.	23.	Simulation of a full wave-controlled rectifier using Simulink	CO3, CO4, CO5
LSOs 5.9 Plot various waveforms of a bridge-controlled rectifier from simulated model.	24.	Simulation of Bridge Controlled Rectifier using Simulink	CO3, CO4, CO5

L) Suggested Term Work and Self-Learning: S2420405 Some sample suggested assignments, micro projects and other activities are mentioned here for reference.

(a) **Assignments**:

- Draw symbols as per IEC/ ANSI standards.
- Draw the symbols of the different semiconductor devices used as switch.
- Draw the diagram of electric series board for testing electrical equipment.
- Draw the front view and plan of a three-phase core type distribution transformer in AUTOCAD.
- Draw sectional view for the different types of lighting arrestor used in HV, EHV and UHV S/S yard in AUTOCAD.
- Obtain output waveforms for various converters in MATLAB / Simulink.
- Plot speed torque characteristics of 3-phase induction motor in Simulink.
- Plot polar plot in MATLAB for a given transfer function.

(b) Micro Projects:

i. Draw the power and control circuit wiring diagram for autotransformer starting of 3- phase Induction motor and demonstrate the circuit implementation in lab.
ii. Draw the earthing layout for a 33/11kV switchyard showing the equipment and neutral equipment if any.
iii. Draw plan and sectional view of 132/33 kV grid AIS substation in AUTOCAD nearest to your city with proper dimensioning.
iv. Draw cable trench layout of 400kV grid AIS substation in AUTOCAD and estimate the bill of

quantities.

v. Draw the free hand sketch of the CT/PT metering equipment installed at the college electrical switch yard.

vi. Simulation of PV Cell in MATLAB and Obtaining V-I Characteristics

vii. Plot various characteristics with respect to irradiation for single diode model of solar PV cell in MATLAB.

viii. Obtain output voltages of two-level three-phase inverter using sine PWM technique in Simulink.

ix. Draw a model of wind power generator using MATLAB/ Simulink.

(c) Other Activities:

1. Seminar Topics:
   - Types of earthing and their importance.
   - Clearances required to maintain in HV/ EHV substations.
   - 3-d modeling of electrical equipment, and their related software.
   - Functions of Simscape components of MATALB.

2. Self-learning topics:
   - 3D software to make electrical components like Inventor.
   - 3D software to make 3-D plans and sectional of substations using Bentley software.
   - Fault analysis of IEEE 9 bus system in MATLAB.

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

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	-	-	15%	-	-	20%	20%
CO-2	-	-	10%	25%	-	10%	20%
CO-3	-	-	15%	25%	33%	15%	20%
CO-4	-	-	30%	25%	33%	15%	20%
CO-5	-	-	30%	25%	34%	40%	20%
Total Marks	-	-	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

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

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: (Not Applicable)

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Symbols and notation of electrical equipment and measuring instruments commonly used in lab conforming to IS standards	CO1	30	60	10
2.	Layout of a typical classroom showing the location of fans, light fixtures, switch boards, distribution boards	CO1	40	50	10
3.	Drawing of Foundation plan as per dimensions for installation of an 11/0.415kV distribution transformer for rating above 500 kVA.	CO1	50	40	10
4.	Drawing of Plate and pipe earthing installation confirming to IS standards.	CO1	50	40	10
5.	Drawing Electrical and Electronic symbols in AutoCAD	CO2	50	40	10
6.	Drawing of Electrical feeder layout of the college in AutoCAD	CO2	50	40	10
7.	Drawing of typical LT and HT cable trench details in AutoCAD	CO2	50	40	10
8.	Basic operation on matrices; such as addition, subtraction, multiplication using MATLAB	CO3	50	40	10
9.	MATLAB program to Generate Various signals such as Unit impulse, unit step, square, saw tooth, triangular, sinusoidal, ramp etc.	CO3	50	40	10
10.	MATLAB program for Perform functions and operations using variables and arrays to learn about relational and logical operators	CO3	50	40	10
11.	MATLAB program for operations on signals and sequences such as addition, multiplication, scaling, shifting, folding.	CO3	50	40	10
12.	MATLAB program to perform functions and operations using variables and arrays to learn about trigonometric and exponential manipulations	CO3	50	40	10
13.	MATLAB program for plotting and labelling 2 dimensional functions like Sin(t), Cos(t), Tan(t) and Sec(t) etc., for a given duration	CO3	50	40	10
14.	MATLAB program to Perform functions and operations using variables and arrays to learn about relational and logical operators	CO4	50	40	10
15.	MATLAB program to plot pole zero pattern for a given transfer function	CO3, CO4, CO5	50	40	10
16.	Node and loop analysis of the given electrical network using Simulink	CO3, CO4, CO5	50	40	10
17.	Application of network theorems such as Thevenin's, Norton's, Superposition etc. to electrical networks using Simulink	CO3, CO4, CO5	50	40	10
18.	Locate the zeros and poles and plotting the pole zero maps in s-plane and z-plane for the given transfer function using MATLAB/Simulink	CO3, CO4, CO5	50	40	10
19.	Simulation of Series and Parallel resonant circuit using Simulink	CO3, CO4, CO5	50	40	10
20.	Simulation of Half Wave rectifier using Simulink	CO3, CO4, CO5	50	40	10

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
21.	Simulation of single-phase diode bridge rectifiers with filter for R and RL loads using Simulink	CO3, CO4, CO5	50	40	10
22.	Simulation of a half wave-controlled rectifier using Simulink	CO3, CO4, CO5	50	40	10
23.	Simulation of a full wave-controlled rectifier using Simulink	CO3, CO4, CO5	50	40	10
24.	Simulation of Bridge Controlled Rectifier using Simulink	CO3, CO4, CO5	50	40	10

Legend:
PRA*: Process Assessment
PDA**: Product Assessment

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	Computer	Personal computer (Intel core i3/ i7/ RAM 16 GB/ HDD) with internet facility and peripheral devices.	1-25
2	AutoCAD Electrical	2017 or latest version	1-7
3	MATLAB along with Electrical related tool boxes	Latest license	8-16
4	Simulink	Simulink should be enabled in MATLAB license	17-25

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Electrical EngineeringDrawing	S.K. Bhattacharya	Second Edition, 2009 New Age InternationalPublisher 978-8122408553
2.	Basic engineering Drawing	M.L.Anwani & I. Anwani	Twenty Third Revised edition 2017, Dhanpat Rai & Sons ISBN:978-8177000191

3.	Computer Aided Electrical Drawing	M Yogesh, B. S Nagaraja, N.Nandan	First edition2014, PHI Learning Pvt. Ltd., Delhi ISBN:978-812034953
4.	AutoCAD Electrical 2018 Black book	Gaurav Verma	Latest edition, BPB Publications, Global Books & Subscription Services ISBN: 9789387284326, 9789387284326
5.	Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers	Rudra Pratap	Seventh edition, 2019, Oxford HED ISBN: 9780190091972
6.	MATLAB and Simulink for Engineers	Agam Kumar Tyagi	First edition 2011, Oxford University Press, India ISBN: 9780198072447, 9780198072447
	Modeling & Simulation Using Matlab Simulink	Shailendra Jain	Latest edition, Wiley India Pvt. Ltd ISBN: 9788126530052, 9788126530052

(b) Online Educational Resources:

1. https://grabcad.com/tutorials
2. http://help.autodesk.com/view/INVNTOR/2014/ENU/
3. http://www.cadtutor.net/tutorials/autocad/
4. http://www.cad-notes.com/contents/autocad-articles/
5. https://www.youtube.com/watch?v=dKDgfdPcHTI
6. https://in.mathworks.com/help/matlab/
7. https://in.mathworks.com/help/simulink/

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational resources before use by the students.

(c) Others:

1. AutoCAD Electrical 2018 Black book by Verma, Gaurav, BPB Publications, Global Books & Services ISBN 9789387284326, 9789387284326
2. Learning Packages
3. Lab Manuals
4. Manufacturers' operating Manual

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A) Course Code : **2400107(T2400107)**

B) Course Title : Professional Ethics (Non-Exam Course)
(CE, CSE, ELX, ELX (R), FTS, ME, ME (Auto), AIML, MIE, CHE, CRE, FPP, GT)

C) Pre- requisite Course(s) : General awareness about moral values and different workplaces

D) Rationale :

One of the programme outcomes of the diploma course incorporates ethical practices in application of appropriate technology in context of society, sustainability, environment. It is of great importance to distinguish between the terms values and ethics. Ethics are norms of behaviour that are set by authorities at workplace. The persons belonging to that workplace are expected to follow the norms. Ethical behaviour at workplace affects the person's relation to people, creates a positive impact on business processes and environment. It is very important that a person has not only understanding of ethical behavior but also the responsibility to set ethical practices in own area of work.

While values are personal preferences or choices, they may sometimes contradict with ethics at his workplace. The values of a person affect behavior and his decision making.

This course is meant to sensitize the student to ethics in profession and motivate them to demonstrate ethical behavior in day to day activities and be aware of ethics in profession.

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 Demonstrate good values and ethics in the day to day activities and at workplace.

CO-2 Identify a set of values and ethics related to fair professional practice.

F) Suggested Course Articulation Matrix (CAM):

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

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

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Board Of Study	Course Code	Course Title	Scheme of Study (Hours/Week)				
			Classroom Instruction (CI)		Notional Hours (TW/ Activities+ SL)	Total Hours (CI+TW/ Activities)	Total Credits (C)
			L	T			
	2400107	Professional Ethics	01	-	-	01	01

Legend:

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

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

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

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

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

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

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

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

I) Theory Session Outcomes (TSOs) and Units: T2400107

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Define concepts-values and ethics and attitude, development of attitudes *TSO 1b.* Identify situations depicting values such as humanity, honesty, punctuality, respect, peace, empathy *TSO 1c.* Identify situations depicting ethics, healthy competition, integrity, truthfulness,	**Unit-1.0 Values and Ethics in Day to Day Life** 1.1. Values- Definition and examples, Ethics- definition and examples, Concept of attitude and development of attitude 1.2. Importance of values and ethics in day to day activities and at workplace- Ethical ways of communication, environmental considerations in engineering processes, Basic concept of Carbon footprint, ethics at workplace 1.3. Examples of situations depicting values- based decisions and ethical behavior in day to Day life	**CO1**
TSO 2a. Identify the relevance of profession to society and environment *TSO 2b.* Identify the need of values and ethics in profession related activities *TSO 2c.* Identify Ethical conflicts	**Unit-2.0 Values and Ethics in Profession** 2.1 Relevance of profession to society 2.2 ethical principles such as respecting others and ourselves, respecting the rights of others, keeping promises, avoiding unnecessary problems to others, avoiding cheating and dishonesty, showing gratitude towards others and encouraging them to work 2.3 Identification of activities and related ethical and unethical behavior for professional activities in their area of work 2.4 Examples of situations depicting values- based decisions and ethical behavior	**CO1, CO2**

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

J) Suggested Activities and Self-Learning: Reading books related to values and ethics/Epics/ Daily news and discussions in group

a. Assignments: Preparation for group discussion, panel discussion, role play, case study, seminar, skits

b. Micro Projects: Skits development and performance, poster making,

c. Activities: Role Play, Case studies, Debates, Group Discussion,

d. Suggested Seminar/ Debates on Topics such as:

i. charters of professions
ii. Importance of Values and ethics in identified profession
iii. Issues of ethical conflicts- Professional rivalry,
iv. Identified issues from Chanakya Neeti
v. Ethics in scriptures such as Kabir ke Dohe etc.
vi. Lessons on ethics from religious scriptures
vii. Issued based on Happenings reported in Daily news

K) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Case Method, Group Discussion, seminar, Role Play, Live Demonstrations in Classrooms, Lab, Expert Session, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

L) List of Major Laboratory Equipment, Tools and Software: (Not Applicable)

M) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Professional Ethics and Human Values	D. R. Kiran	McGraw-Hill Education Pvt. Ltd. 2007 ISBN: 9780070633872
2.	A Textbook On Professional Ethics And Human Values	Dr. R S Naagarazan	New Age International (P) Ltd., Publishers, 2017 ISBN: 9789386173768
3.	Ethics, Integrity and Aptitude – **Hindi** (Paperback) (एथिक्स, सत्यनिष्ठा एवं अभिवृत्ति)	P.D Sharma	Rawat Publications, 2019 ISBN: 978-8131609941
4	Chanakya - Niti (Sutra Sahit) (Hindi)	Chanakya	Maple Press. 2014 ISBN 978-9350335529

(b) Online Educational Resources:

1. Free Ethics & Compliance Toolkit - Ethics and Compliance Initiative (https://www.ethics.org/resources/free-toolkit
2. Free & open source tools for ethics practitioners (https://www.cityethics.org/harvard-lab)
3. Microsoft Word - KPTI XII - Indian Ethics 03-05-13 (https://cbseacademic.nic.in/web_material/doc/ktpi/30_KPTI%20XII%20-%20Indian%20Ethics_old.pdfcbseacademic.nic.in)
4. Knowledge Traditions & Practices of India (cbseacademic.nic.in) (ps://cbseacademic.nic.in/web_material/Circulars/2012/68_KTPI/Module_5.pdf)

(c) Others:

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A) Course Code : 2400207(T2400207)

B) Course Title : Indian Constitution (Common for all Programmes)

C) Pre- requisite Course(s) :

D) Rationale :

This course will focus on the basic structure and operative dimensions of Indian Constitution. It will explore various aspects of the Indian political and legal system from a historical perspective highlighting the various events that led to the making of the Indian Constitution. The Constitution of India is the supreme law of India. The document lays down the framework demarcating the fundamental political code, structure, procedures, powers, and sets out fundamental rights, directive principles, and the duties of citizens. The course on constitution of India highlights key features of Indian Constitution that makes the students a responsible citizen. In this online course, we shall make an effort to understand the history of our constitution, the Constituent Assembly, the drafting of the constitution, the preamble of the constitution that defines the destination that we want to reach through our constitution, the fundamental right constitution guarantees through the great rights revolution, the relationship between fundamental rights and fundamental duties, the futurist goals of the constitution as incorporated in directive principles and the relationship between fundamental rights and directive principles.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course out comes 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 List salient features and characteristics of the constitution of India.

CO-2 Follow fundamental rights and duties as responsible citizen and engineer of the country.

CO-3 Analyze major constitutional amendments in the constitution.

F) Suggested Course Articulation Matrix (CAM):

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

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

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Board of Study	Course Code	Course Title	Scheme of Study (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
	2400207	Indian Constitution	01	-	-	01	01	01

Legend:

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

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

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

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

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

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

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

H) Assessment Scheme:

Board of Study	Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
	2400207	Indian Constitution	25	-	25	-	-	-	50

Legend:

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

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

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

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

J) Theory Session Outcomes (TSOs) and Units: T2400207

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain the meaning of preamble of the constitution. TSO 1b. List the salient features of constitution. TSO 1c. List the characteristics of constitution.	**Unit-1.0 Constitution and Preamble** 1.1 Meaning of the constitution of India. 1.2 Historical perspective of the Constitution of India. 1.3 Salient features and characteristics of the Constitution of India. 1.4 Preamble to the Constitution of India.	**CO1**
TSO 2a. Enlist the fundamental rights. *TSO 2b.* Identify fundamental duties in general and in particular with engineering field. *TSO 2c.* identify situations where directive principles prevail over fundamental rights.	**Unit-2.0 Fundamental Rights and Directive Principles** 2.1 Fundamental Rights under Part-III. 2.2 Fundamental duties and their significance. 2.3 Relevance of Directive Principles of State Policy under part-IV.	**CO2**
TSO 3a. Enlist the constitutional amendments. *TSO 3b.* Analyze the purposes of various amendments.	**Unit-3.0 Governance and Amendments** 3.1 Amendment of the Constitutional Powers and Procedure 3.2 Major Constitutional Amendment procedure - 42nd, 44th, 74th, 76th, 86th and 91st	**CO3**

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: (Not Applicable)

L) Suggested Term Work and Self Learning: Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

b. Micro Projects:

1. Role of Media in Spreading Awareness regarding Fundamental Rights
2. Analysis of Situations where directive principle of State policy has prevailed over Fundamental rights
3. Analyze 42nd and 97th Amendment of Indian Constitution

c. Other Activities:

1. Seminar Topics:
   - Democracy and Political Participation in India
   - Situations where directive principles prevail over fundamental rights.
2. Visits:
   - Arrange Mock Parliament.
3. Design games and simulation on emergencies declared in last thirty years.
4. Group discussions on current print articles.
   - Adoption of Article 365 in India.
   - Need of amendments in the constitution.

5. Prepare collage/posters on current constitutional issues.
   - Emergencies declared in India
   - Seven fundamental rights

6. Cases: Suggestive cases for usage in teaching:

Case	Relevance
A.K. Gopalan Case (1950)	SC contented that there was no violation of Fundamental Rights enshrined in Articles 13, 19, 21 and 22 under the provisions of the Preventive Detention Act, if the detention was as per the procedure established by law. Here, the SC took a narrow view of Article 21.
Shankari Prasad Case (1951)	This case dealt with the amendability of Fundamental Rights (the First Amendment's validity was challenged). The SC contended that the Parliament's power to amend under Article 368 also includes the power to amend the Fundamental Rights guaranteed in Part III of the Constitution.
Minerva Mills case (1980)	This case again strengthens the Basic Structure doctrine. The judgement struck down 2 changes made to the Constitution by the 42nd Amendment Act 1976, declaring them to violate the basic structure. The judgement makes it clear that the Constitution, and not the Parliament is supreme.
Maneka Gandhi case (1978)	A main issue in this case was whether the right to go abroad is a part of the Right to Personal Liberty under Article 21. The SC held that it is included in the Right to Personal Liberty. The SC also ruled that the mere existence of an enabling law was not enough to restrain personal liberty. Such a law must also be "just, fair and reasonable."

7. Self-learning topics:

- Parts of the constitution and a brief discussion of each part.
- Right to education.
- Right to equality.

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

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	30%	-	30%	-	-	-	-
CO-2	40%	-	40%	50%	50%	-	-
CO-3	30%		30%	50%	50%		
Total Marks	25	-	5	10	10	-	-
			25				

Legend:
*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.
**: Mentioned under point- (N)
#: Mentioned under point-(O)
Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: (Not Applicable)

O) Suggested AssessmentTable for Laboratory (Practical): (Not Applicable)

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

Q) List of Major Laboratory Equipment, Tools and Software: (Not Applicable)

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	The Constitution of India	P.M.Bakshi	Universal Law Publishing, New Delhi 15th edition, 2018, ISBN: 9386515105
2.	Introduction to Indian Constitution	D.D.Basu	Lexis Nexis Publisher, New Delhi, 2015, ISBN:935143446X
3.	Introduction to Constitution of India	B. K. Sharma	PHI, New Delhi, 6thedition, 2011, ISBN:8120344197
4.	The Constitution of India	B.L. Fadia	Sahitya Bhawan,Agra, 2017, ISBN:8193413768
5.	The Constitutional Law of India	Durga Das Basu	LexisNexis Butterworths Wadhwa, Nagpur 978-81-8038-426-4

(b) Online Educational Resources:

1. https://www.coursera.org/learn/principles-of-management
2. http://www.legislative.gov.in/constitution-of-india
3. https://en.wikipedia.org/wiki/Constitution_of_India
4. https://www.india.gov.in/my-government/constitution-india
5. https://eci.gov.in/about/about-eci/the-setup-r1/
6. https://www.toppr.com/guides/civics/the-indian-constitution/the-constitution-of-india/
7. https://main.sci.gov.in/constitution
8. https://nios.ac.in/media/documents/srsec317newE/317EL8.pdf
9. https://legalaffairs.gov.in/sites/default/files/chapter%203.pdf
10. https://www.concourt.am/armenian/legal_resources/world_constitutions/constit/india/india-e.htm
11. https://constitutionnet.org/vl/item/basic-structure-indian-constitution

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(c) Others:

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A) Course Code : **2400108(T2400108)**

B) Course Title : Essence of Indian Knowledge System and Tradition (Common for all Programmes)

C) Pre- requisite Course(s) :

D) Rationale :

This course will survey the basic structure and operative dimensions of Indian knowledge system. With the new education policy-NEP 2020 focusing on Indian Knowledge Systems (IKS) and Traditions of India. This course introduces the learners to the rich and varied knowledge traditions of India from antiquity to the present. This also helps the learner to know and understand their own systems and traditions which are imperative for any real development and progress. Also, it helps the learner to think independently and originally adopting Indian frameworks and models for solving the problems related to world of work where the student is supposed to perform.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course out comes 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 Identify the rich heritage and legacy residing in our Indian Knowledge systems.

CO-2 Correlate the technological & philosophical concepts of IKS with engineering domain specific problems and local problems for finding out possible solutions.

F) Suggested Course Articulation Matrix (CAM):

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

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

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Board of Study	Course Code	Course Title	Scheme of Study (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
	2400108	Essence of Indian Knowledge System and Tradition	01	-	-	01	01	01

Legend:

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

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

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

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

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

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

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

H) Assessment Scheme:

Board of Study	Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment (TA)		Term Work& Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
	2400108	Essence of Indian Knowledge System and Tradition	25	-	-	-	-	-	25

Legend:

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

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

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

I) Course Curriculum Detailing:

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

J) Theory Session Outcomes (TSOs) and Units: T2400108

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain the architecture of the Ancient Indian Knowledge Systems. *TSO 1b.* List the salient features of IKS. *TSO 1c.* Comprehend the given IKS model. *TSO 1d.* Identify the role and relevance of the given IKS model in contemporary society.	**Unit-1.0 Introduction to Indian Knowledge Systems** 1.1 Overview of IKS 1.2 Organization of IKS – चतुर्दश-विद्यास्थानं 1.3 Conception and Constitution of Knowledge in Indian Tradition 1.4 The Oral Tradition 1.5 Models and Strategies of IKS	**CO1**
TSO 2a. Enlist the importance of Veda, Vedanga, Visaya, Siksaka. *TSO 2b.* Describe the given IKS domain. *TSO 2c.* Identify elements of mentioned IKS domains that are relevant to Technical Education System. *TSO 2d.* Correlate the elements of mentioned IKS domains with given engineering domain.	**Unit-2.0 Overview of IKS Domains and Relevance in Current Technical Education System.** 2.1 The Vedas as the basis of IKS 2.2 Overview of all the six Vedāṅgas 2.3 Relevance of following IKS domains in present Technical Education System: • Arthashastra (Indian economics and political systems) • Ganita and Jyamiti (Indian Mathematics, Astronomy and Geometry • Rasayana (Indian Chemical Sciences) • Ayurveda (Indian Biological Sciences / Diet & Nutrition) • Jyotish Vidya (Observational astronomy and calendar systems) • Prakriti Vidya (Indian system of Terrestrial/ Material Sciences/ Ecology and Atmospheric Sciences) • Vastu Vidya (Indian system of Aesthetics- Iconography and built-environment /Architecture) • Nyaya Shastra (Indian systems of Social Ethics, Logic and Law) • Shilpa and Natya Shastra (Indian Classical Arts: Performing and Fine Arts) • Sankhya and Yoga Darshna (Indian psychology, Yoga and consciousness studies) • Vrikshayurveda (Plant Science / Sustainable agriculture/food preservation methods)	**CO1, CO2**

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: (Not Applicable)

L) Suggested Term Work and Self Learning: Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

b. Micro Projects:

1. Write a report on any IKS domain highlighting the correlation with one domain specific engineering course.

c. Other Activities:

1. Seminar Topics: discuss any one IKS domain in details a highlighting the eminent works in the area.
2. Visits:
   - Visit any nearby ancient temple and corelate the geomatical, Shilpa and Vaastu on IKS dimensions specified in each domain.
3. Self-learning topics:
   - Sustainable practices adopted in ancient India that can be applied for current engineering situations.

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

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	-	-	-	-	-	-	-
CO-2	100%	-	100%	100%	100%	-	-
Total Marks	25	-	5	10	10	-	-
			25				

Legend:

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

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: (Not Applicable)

O) Suggested AssessmentTable for Laboratory (Practical): (Not Applicable)

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

Q) List of Major Laboratory Equipment, Tools and Software: (Not Applicable)

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Introduction to Indian Knowledge System: Concepts and Applications	Archak, K.B. (2012).	Kaveri Books, New Delhi
2.	Introduction to Indian Knowledge System: Concepts and Applications	Mahadevan, B. Bhat, Vinayak Rajat Nagendra Pavana R.N.	PHI, ISBN: 9789391818203
3.	Glimpse into Kautilya's Arthashastra	Ramachandrudu P. (2010)	Sanskrit Academy, Hyderabad
4.	"Introduction" in Studies in Epics and Purāṇas, (Eds.)	KM Munshi and N Chandrashekara Aiyer	Bhartiya Vidya Bhavan

(b) Online Educational Resources:

1. http://bhavana.org.in
2. www.academia.edu/23254393/Science_in_Ancient_India_-_an_educational_module
3. www.academia.edu/23305766/Technology_in_Ancient_India_-_Michel_Danino
4. www.hamsi.org.nz/http://insaindia.res.in/journals/ijhs.php
5. www.niscair.res.in/sciencecommunication/ResearchJournals/rejour/ijtk/ijtk0.asp
6. www-history.mcs.st-andrews.ac.uk/Indexes/Indians.html

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

(c) Others:

1. Swami Harshananda. "A bird's eye view of vedas". R K Math. Bangalore.,http:// rkmathbangalore. org/Books/ABirdsEyeViewOfTheVedas.pdf.
2. Sanskrit Prosody, https://en.wikipedia.org/wiki/Sanskrit_prosody.
3. Vartak, P.V. (1995). "Veda and Jyotish," Part II, Chapter 2, in Issues in Veda and Astrology, H Pandya (Ed.), pp 65 – 73.
4. Sundaram, A.V. (1995). "Astrology: Its usefulness and Limitations in ModernTimes", Part II, Chapter 9, in Issues in Veda and Astrology, H Pandya (Ed.), pp 129 – 135.
5. Archak, K.B. (2012), "The Vedāṅga Literature", Chapter VIII in Essentials of Vedic Literature, Kaveri Books, New Delhi, pp 330 – 391.
6. Vasant Lad (1996), "Ayurveda: A Brief Introduction and Guide", (whole article).

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