Curriculum of Diploma Programme

in

Textile Technology

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

State Board of Technical Education (SBTE), Bihar

Semester – VI
Teaching & Learning Scheme

Course Codes	Category of course	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				
2453605	**PCC**	**Non-woven and Knitting Technology**	03	-	-	-	03	03
2428602	**PCC**	**Textile Management and Safety**	02	01	-	02	05	04
2428603	**PEC**	**Program Electives*** - Any One	02	01	-	02	05	04
2400604	**OEC**	**Open Electives** / COE** (Advanced – Any One)	03	-	04	02	09	06
2428601	**PCC**	**Technical Textiles**	02	01	-	02	05	04
2428606	**PSI**	**Major Project** (Common for all programmes)	-	-	08	04	12	06
2428607	**NRC**	**Basics of IPR** (FCT, TE)	02	-	-	-	02	02
2400408	**NRC**	**Employability Skills Development** (Common for All Programmes)	01	-	-	-	01	01
Total			**15**	**03**	**12**	**12**	**42**	**30**

Note: Prefix will be added to Course Code if applicable (T for Theory, P for Practical Paper and S for Term Work)

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)

*: Advanced Yarn and Fabric Manufacturing /Sericulture and Silk Technology / Smart Textile / Nonwoven & Knitting

**: 3D Printing & Design/ Artificial Intelligence (AI)/ Drone Technology / Electric Vehicle / Industrial Automation & Control/ Robotics/ Internet of Things/Transformer Manufacturing and Repairing/Optical Fiber and 5G Communication

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 - VI
Assessment Scheme

Course Codes	Category of course	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)	
2453605	**PCC**	**Non-woven and Knitting Technology**	30	70	-	-	-	-	100
2428602	**PCC**	**Textile Management and Safety**	30	70	20	30	-	-	150
2428603	**PEC**	**Program Electives*** - Any One	30	70	20	30	-	-	150
2400604	**OEC**	**Open Electives** / COE** (Advanced – Any One)	30	70	20	30	20	30	200
2428601	**PCC**	**Technical Textiles**	30	70	20	30	-	-	150
2428606	**PSI**	**Major Project** (Common for all programmes)	-	-	20	30	50	100	200
2428607	**NRC**	**Basics of IPR** (FCT, TE)	25	-	-	-	-	-	25
2400408	**NRC**	**Employability Skills Development** (Common for All Programmes)	25	-	-	-	-	-	25
Total			**200**	**350**	**100**	**150**	**70**	**130**	**1000**

Note: Prefix will be added to Course Code if applicable (T for Theory, P for Practical Paper and S for Term Work)

Legend:

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

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

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.

*: Advanced Yarn and Fabric Manufacturing /Sericulture and Silk Technology / Smart Textile / Nonwoven & Knitting

**: 3D Printing & Design/ Artificial Intelligence (AI)/ Drone Technology / Electric Vehicle / Industrial Automation & Control/ Robotics/ Internet of Things/Transformer Manufacturing and Repairing/Optical Fiber and 5G Communication

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 : **2453605 (T2453605)**

B) Course Title : Non-woven and Knitting Technology

C) Pre- requisite Course(s) : Textile Fibres

D) Rationale :

Nonwoven fabrics can be used in a wide variety of applications like consumer products, industrial products and medical & healthcare products. During the past few years, the use of nonwoven has grown rapidly. The selection of the right material is very important while manufacturing nonwoven products. The selection of material depends upon the required function, nature and severity. Knitting is a comparatively faster and more economical process to convert yarn into fabric. Due to their unique features of stretchability, thermal properties, comfort and other favorable properties knitted fabrics are in good demand and are being used for undergarments, sports uniforms, summer and winter dresses etc. to a large extent. Knitting can produce a wide range of fabrics and products suitable for intimate wear to technical textiles including 3-D fabrics as well as medical textiles including human body implants. Therefore, the textile technology students need to know all the relevant technical knowledge for the manufacturing of knitted fabrics and nonwovens and the machines used for their manufacturing.

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

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

- **CO-1** Select the relevant web-forming process for the manufacturing of a given nonwoven.
- **CO-2** Select relevant web bonding methods to produce given non-woven fabrics.
- **CO-3** Suggest relevant types of knitted fabric for given application.
- **CO-4** Apply the knowledge of circular and flat knitting machines to knit the fabric.
- **CO-5** Apply the knowledge of the warp knitting machine to knit the fabric.

F) Suggested Course Articulation Matrix (CAM):

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

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

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

G) Teaching & Learning Scheme:

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				
2453605	Non-woven and Knitting Technology	03	-	-	-	03	03

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies, 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= (1xCIhours) + (0.5xLIhours) + (0.5xNotionalhours)

Note: TWandSLhavetobeplannedbytheteacherandperformedbythelearnerunderthecontinuousguidanceandfeedbackofteachertoensure the outcome of learning.

H) Assessment Scheme:

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)	
2453605	Non-woven and Knitting Technology	30	70	-	-	--	--	100

Legend:

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

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

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

Note:

Separate passing is a must for progressive and end-semester assessment for both theory and practical.

ETA & ELA are to be carried out at the end of the term/ semester.

Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done internally (40%) as well as externally (60%). Assessment related to planning and execution of Term Work activities like assignments, micro-projects, seminars 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 for internal as well as external assessment may vary as per the requirement of the respective course. For valid and reliable assessment, the internal faculty should prepare a 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 the attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020-related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: T2453605

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Define the term non-woven. TSO 1b. Explain the sequence of the manufacturing process of the given non-woven fabrics. TSO 1c. Compare the features of the given non-woven structures and manufacturing process flow chart. TSO 1d. Draw a flow chart for the preparation of the different web formations. TSO 1e. Discuss different fibres and their properties used to produce non-woven fabrics. TSO 1f. Explain the different applications of non-woven fabrics. TSO 1g. Describe the characteristics of given non-woven fabric.	**Unit-1.0 Introduction to Nonwoven** 1.**1 Introduction, Definition, Properties, Products, Market Overview and Growth Projections of** Nonwoven 1.2 Classification of nonwovens: Dry-laid, Wet-laid, Spun-laid and Melt blown nonwovens 1.3 Manufacturing process: Web formation, Web bonding and Finishing treatments 1.4 Web forming process: Parallel laid webs, Cross laid webs, Random laid webs, Air laid webs 1.5 Raw materials and their properties used to produce nonwovens 1.6 Characteristics and applications of nonwovens	**CO1**
TSO 2a. Explain different web bonding methods. *TSO 2b.* Explain the properties required for the given application of non-woven fabric. *TSO 2c.* Discuss the applications of Spun bond and Melt-blown non-woven fabrics. *TSO 2d.* Describe different finishes used for non-woven fabrics. *TSO 2e.* Describe the web bonding process for the given type of fibre.	**Unit-2.0 Web Bonding Methods of Nonwoven** 2.1 Thermal bonding: Principle, Methods -Hot calendaring (Area bonding, Point bonding and Embossing), Belt calendaring, Through-air bonding, Ultrasonic bonding, Thermally bonded fabric structure, Applications of thermally bonded fabrics 2.2 Chemical (Adhesive) bonding: Bonding process, methods of binder application – Saturation, Foam, Spray, Print and Powder bonding, Applications of chemically bonded nonwovens 2.3 Spun bonding: Principles, process of manufacturing and physical properties of spun bonded fabrics 2.4 Mechanical bonding: Stitch bonding system, Needle punching technology and Hydroentanglement process technology 2.5 Needle punching: Basics of needle punching (needle loom) operation, up-punching, down punching, single needle board, multi-needle board, needle design and selection, needle reduction, needle type and specifications, punch density, applications of needle punched nonwovens 2.6 Spunlace nonwovens (Hydroentanglement): Process, Properties and Applications of spunlaced fabrics	**CO2**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 3a. Describe the fabric formation by knitting techniques with sketches. TSO 3b. Define the basic terms in knitting. TSO 3c. Compare weaving and knitting. TSO 3d. Discuss the advantages of knitted fabrics. TSO 3e. Compare warp knitting and weft knitting on given parameters.	**Unit-3.0 Knitting Technology** 3.1 Introduction, knitting techniques, definitions of basic terms used in knitting - courses, wales, face loop, back loop, needle loop, sinker loop, technical face, technical back, stitch density, stitch length, course length, open loop, close loop 3.2 Properties of Knitted Fabrics, Comparison of weaving and knitting 3.3 Classification: Warp knitting and Weft knitting, comparison of warp knitting and weft knitting concerning process, structure and properties 3.4 Classification of knitting machines: Weft knitting machine and Warp knitting machine	**CO3**
TSO 4a. Explain the basic structures of weft knitted fabric with sketches. TSO 4b. Compare different types of knitting needles with their merits and limitations. TSO 4c. Explain the functioning of elements of a given weft knitting machine with sketches. TSO 4d. Describe the knitting cycle for the given type of needle with sketches. TSO 4e. Describe the passage of yarn for the given type of knitting machine. TSO 4f. Explain the knitting process for the given type of knitting machine. TSO 4g. Distinguish the knitting process for the given knitting machines based on the principle of knitting. TSO 4h. Explain the characteristics of the given type of weft-knitted fabric.	**Unit-4.0 Weft Knitting** 4.1 Weft knit structures: Symbolic representation, features and properties of plain, rib, interlock and purl knit structure, ornamentation of plain-knit fabrics – using variation in yarn colour, count, twist and material, derivatives of plain knit (Single Jersey) – Knit and float, Knit and tuck, Knit, float and tuck 4.2 Needle Types: Latch needle, Bearded needle, Compound needle, advantages and limitations of each needle 4.3 Classification of Weft knitting machines: Flat knitting machine: Passage, knitting elements and knitting cycle Single jersey circular knitting machine: Passage, knitting elements- Needle, Sinker, Cams, Cylinder, Feed yarn carriers, Take-up mechanism, Operation Cycle – Clearing, Feeding, Knitting Position Double jersey (Rib, Interlock and Purl) circular knitting machine: Trick, cam, needle arrangement of cylinder and dial, operation cycle- Rest, Clearing, Feeding, Knitting Position 4.4 Characteristics of single jersey, rib, interlock and purl knit structure	**CO4**
TSO 5a. Describe the functions of elements of the given warp knitting machine. TSO 5b. Explain the passage, knitting elements and knitting cycle for the given type of warp knitting machine with sketches. TSO 5c. Describe with sketches the representations of the given warp-knit structures. TSO 5d. Determine the stitch length of the given fabric. TSO 5e. Calculate the production of the given knitting machine.	**Unit-5.0 Warp Knitting** 5.1 Basic warp knitting terms: overlap, underlap, open and closed lap 5.2 Classification of warp knitting machines- Tricot Machine, Raschel Machine: Knitting elements - needle bar, guide bar, sinker bar, pattern wheel, chain link and knitting cycle for latch and compound needle 5.3 Comparison of Tricot and Raschel Machines and Fabrics 5.4 Methods of representation – lapping movement and chain notation	**CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 5f. Determine the tightness factor of the given fabric. TSO 5g. Describe the given knitted fabric defect, its causes and remedies.	5.5 Notations of warp knit structures: Pillar, Atlas, Tricot, Locknit, Sateen, reverse Locknut 5.6 Applications of warp-knitted Fabric 5.7 Important knitted fabric defects and their remedies 5.8 Calculations	

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-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.

1. Prepare a report on different fibres used in nonwoven.
2. Prepare a report on various types of nonwoven products, manufacturing processes, properties and applications in consumer products.
3. Prepare a report on various types of nonwoven products, manufacturing processes, properties and applications in industrial products.
4. Prepare a report on various types of nonwoven products, manufacturing processes, properties and applications in medical and healthcare products.
5. Prepare a comparative chart of different web bonding techniques.
6. Prepare a report on various types of needles used in knitting and write their specification.
7. Prepare a report on recent developments in knitting technology.
8. Prepare a report on weft-knitted structures for industrial applications.
9. List down common knitting faults.
10. Prepare a report on the application of knitted fabrics in technical and medical textiles.

b. Micro Projects:

1. Collect at least five samples of nonwoven products used as industrial products and prepare a booklet showing the special features for selecting the fabric for the relevant application.
2. Collect at least five samples of nonwoven products used as consumer products and prepare a booklet showing the special features for selecting the fabric for the relevant application.
3. Collect at least five samples of nonwoven products used as medical and healthcare products and prepare a booklet showing the special features for selecting the fabric for the relevant application.
4. Draw a detailed classification chart of fibre used in the nonwoven industry with examples of each variety.
5. Collect the information on different fibres used in nonwoven medical products by doing a local market survey and preparing a report.
6. Collect various samples of nonwoven filter fabrics study the Physical and chemical properties of filter fabrics and prepare a compile report.
7. Collect at least five knitted fabric samples according to end use and study their knit structure. Prepare a report on the knit structure used according to end-use.
8. Collect various types of needles and prepare a booklet by writing their specification.

Collect specifications of warp and weft knitting machines of different manufacturers and prepare a comparative chart.

c. Other Activities:

1. Seminar Topics:
   - Applications of nonwovens in technical textiles
   - Classification of nonwovens based on structure
   - Fibres used in the nonwoven industry
   - Types and suitability of yarns for knitting
   - Warp knitting technology and products
   - Advances in circular knitting
   - Faults their causes and remedies in knitted fabrics
   - Automation in weft knitting technology

2. Visits: Visit nearby nonwoven and knitting industry with modern types of machinery facilities and Prepare a report of the visit with special comments on modern machinery used, material used, single component/ batch production/ mass production and cost of production.

3. Self-learning topics:
   - Future trends of nonwovens
   - Nonwoven in medical textiles
   - Application of nonwoven in a car
   - Bi-component fibres
   - Recent developments in knitting technology
   - 3D Knitting Technology
   - Thermal comfort properties of knitted structures

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use the appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of 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%					
CO-2	30%	30%					
CO-3	10%	10%					
CO-4	20%	20%					
CO-5	20%	20%					
Total Marks	**30**	**70**					

Legend:

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

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

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

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

Unit Title and Number	Total Classroom Instruction (Cl) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Introduction to Nonwoven	10	CO1	14	4	5	5
Unit-2.0 Web Bonding Methods and Finishing of Nonwovens	14	CO2	20	4	6	10
Unit-3.0 Introduction to Knitting	06	CO3	10	2	4	4
Unit-4.0 Weft Knitting	09	CO4	13	4	4	5
Unit-5.0 Warp Knitting	09	CO5	13	4	5	4
Total	**48**	**-**	**70**	**18**	**24**	**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): 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:

Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
	Handbook of Nonwovens	Russell S	Woodhead Publishing, India ISBN: 9781855736030
	Introduction to Nonwovens Technology	Batra, K.S. & Pourdeyhimi, B.	Destech Pubns Inc ISBN: 9781845696917
	Needle-punching	Purdy, A.T.	North Carolina State University ISBN: 9780900739323
	Nonwoven Fabrics: Raw Materials, Manufacture, Applications, Characteristics, Testing Processes	Albrecht, W., Fuchs, H. & Kittelmann.W	Wiley-VCH Verlag GmbH; 1st edition ISBN: 9783527304099
	Knitting Technology	Ajgaonkar, D.B.	Universal Publishing Corpn. ISBN:9788185027340
	Knitting Fundamentals, Machines, Structures and Developments	Anbumani, N.	New Age International Publishers ISBN: 9788122419542
	Knitting Technology	Spencer, J. David	Woodhead Publication Ltd. ISBN: 9781855733336

	Warp Knit Engineering	Reisfeld, A.	The Textile Institute, CRC Press, 1999 ISBN: 9781870372213
	Circular Knitting Technology	Iyer Chandrshekhar	Meisenbach, 1992 ISBN: 9783875250558

(b) Online Educational Resources:

https://archive.nptel.ac.in/courses/116/102/116102014/
https://archive.nptel.ac.in/courses/116/102/116102008/
https://archive.nptel.ac.in/courses/116/102/116102056/
https://www.textiletoday.com.bd/types-non-woven-fabrics-manufacturing-processes-applications
https://www.textileschool.com/352/non-woven-fabrics/
https://textilelearner.net/uses-of-non-woven-fabrics/
https://textiletutorials.com/knitting-technology-definition-and-types-of-knitting/
https://textilestudycenter.com/flat-knitting-technology/

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:

The Textile Institute Book Series
Autex Research Journal
Woodhead Publishing Series in Textiles

S) Course Curriculum Development Team (SBTE, Patna)

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A) Course Code : **2428602 (T2428602/S2428602)**

B) Course Title : Textile Management and Safety

C) Pre-requisite Course(s) : Yarn Manufacture – I & II, Fabric Manufacture – I & II

D) Rationale :

Diploma engineers deal with various important issues to manage the Textile Industry. The managerial aspects like Man power requirement, Productivity management content will help to take effective decision. The calculations regarding production and machinery allocation in spinning, weaving, processing and composite mills covered in this course will be helpful in day to day working plan in a textile mill. It also covers various aspects of labour required, Maintenance, Material handling and Safety in textile mills for producing cost effective product. This course is developed in such a way that basic concepts and principles of textile management will help the diploma engineer to get maximum production by proper utilization of space and machine.

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

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

CO-1 Use operation principles to control the textile mill processes by using relevant management principles.

CO-2 Select site and plant & machinery layout for a given type of textile mill.

CO-3 Organize material and machine production for Textile mills.

CO-4 **Select the optimum manpower required for the spinning and weaving department.**

CO-5 Use effective maintenance and material handling equipment considering safety measure in the textile industry for cost effective production.

F) Suggested Course Articulation Matrix (CAM):

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

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				
2428602	Textile Management and Safety	02	01	-	02	05	04

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:

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)	
2428602	Textile Management and Safety	30	70	20	30	---	---	150

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: T2428602

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain the objects & function of textile management. *TSO 1b.* Describe the profile of Indian Textile Industry. *TSO 1c.* Describe the role of Technical and Managerial resources in Textile Industry. *TSO 1d.* Explain the primary principles of Textile Management. *TSO 1e.* Suggest remedies for the management problems identified in the Textile Industry.	**Unit-1.0 Introduction to Textile Management** 1.1 Objects of Textile Management. 1.2 Functions of Textile management: Planning, organizing, leading/directing, staffing and controlling. 1.3 A Brief Profile of Indian Textile Industry, Its importance, Management Problems of Indian Textile Industry and their remedies. 1.4 Industry as a Social System, Technocracy and Management. 1.5 Primary Principles of Textile Management.	**CO1**
TSO 2a. Identify the various factors considered for site selection for the given situation with justification. *TSO 2b.* Describe the need of SEZ (Special Economic Zone) and cluster development for the given type of textile industry. *TSO 2c.* Describe the purpose of plant and machinery layout for the given situation. *TSO 2d.* Differentiate between good layout and bad layout. *TSO 2e.* Describe the features, advantages and limitations of process layout and product layout. *TSO 2f.* Estimate the storage space requirements. *TSO 2g.* Describe various factors influencing layouts and selection of machinery for the given situation. *TSO 2h.* Prepare the plant and machinery layout for the given spinning and weaving industries. *TSO 2i.* Draw the flow chart showing lay outs of the given textile mills and unit.	**Unit-2.0 Site Selection, Plant and Machinery Layout for Textile mills** 2.1 Selection of site for textile mills: General location; Actual selection of specific site 2.2 Factors influencing site selection: Climatic considerations, geo-technical report, bearing pressure. 2.3 General information about SEZ, cluster development and its facility. 2.4 Concept of plant and machinery Layout, Objectives of good plant layout. 2.5 Principles of layouts, Types of layouts (Product layout and process layout) and their advantages and limitations, Storage space requirements 2.6 Plant layout procedure, Factors influencing layouts, Selection of layout, advantages of good plant lay out, Effect of automation on plant layout 2.7 Symptoms of bad layout. 2.8 Layout aspects of spinning, weaving, Processing, knitting and composite mills.	**CO2**
TSO 3a. Select relevant machines required with specification to produce specified product in the given textile mill. *TSO 3b.* Prepare the Spin Plan for the given count of yarn. *TSO 3c.* Prepare organization chart for Rotor spinning mill. *TSO 3d.* Select relevant machines with specification required to produce the given fabric of fabric weaving mill. *TSO 3e.* Prepare the Weaving Plan for the given quality of fcloths on specified loom. *TSO 3f.* Calculate the number of automatic looms and preparatory machines in weaving mill	**Unit-3.0 Organization of Textile Mills** 3.1 Selection of machines & machinery specifications required for the product in spinning, weaving, Processing and Composite mills. 3.2 Calculation for no. of machines in spinning /spin plan: Preparation of spin plan for Ring, Open End (Rotor) and Blended yarns. 3.3 Preparation of organization for ring spinning mill and preparatory departments based on ring spindle capacity and production of ring spun yarn (Carded, Combed, Blended and Folded). 3.4 Preparing organization of rotor spinning mill. 3.5 Calculations regarding efficiency, waste, draft, twist, production rates, amount of raw material required and no. of machinery required at different stages of	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
for required quantity production of desired fabric. *TSO 3g.* Estimate the number of shuttleless looms and preparatory machines in weaving mill for required quantity production of the specified fabric.	spinning process. 3.6 Calculation for no. of machines in weaving / weave plan: Preparation of organization/weaving plan for shuttle & shuttleless weaving mill and preparatory departments based on number of weaving machines & production of different quality of cloths. 3.7 Calculation regarding efficiency, waste, crimp, production rates, raw material and no. of machinery required at different weaving processes.	
TSO 4a. Identify the types of labour required in textile mills. TSO 4b. Estimate the requirement of the skilled, unskilled labour for the given deparments of spinning, weaving, processing and Composite mills based on work load consideration. TSO 4c. Describe the duties of the given skilled manpower in spinning and weaving mills. TSO 4d. Explain the duties/functions of technical and administrative man power in textile mills. TSO 4e. Describe the qualities of technical and administrative manpower in textile mills. TSO 4f. Describe concept and principle of work study, motion study and snap study. TSO 4g. Explain the need and importance of Human Resource management for the given purposes.	**Unit-4.0 Labour Complement in Textile Mills** 4.1 Types of labour 4.2 Labour compliment, labour and staff required for spinning, weaving, processing and Composite mills based on workload consideration. 4.3 Operative duties of skilled man power in spinning and weaving mills. 4.4 Operative duties/functions of technical and administrative manpower in textile mills. 4.5 Qualities of technical and administrative manpower in textile mills. 4.6 Concept and principle of – Work study, Motion study and Snap study. 4.7 Basic Concepts of Recruitment, Employee training, Motivation, Wages, incentive schemes, compensation, grievances, Trade union and collective bargaining.	**CO4**
TSO 5a. Classify different types of costs. *TSO 5b.* Explain the different elements of costing in textile mills. *TSO 5c.* Describe various costing methods. *TSO 5d.* Estimate the standard costing of given textile materials. *TSO 5e.* Suggest the cost reduction techniques for a given scenario. *TSO 5f.* Describe different types of maintenance in the textile industries. *TSO 5g.* Compare between preventive and breakdown maintenance. *TSO 5h.* Explain the various factors on which proper selection of a material handling device depend. ***TSO 5i.*** **Prepare the safety charts for the given department.** *TSO 5j.* **Suggest the precautionary measures for the given health hazards.**	**Unit-5.0 Costing, Maintenance, Material handling and Safety in Textile Industry** 5.1 Cost concept, definition and classification of costs. 5.2 Elements of Cost, Methods and techniques of costing 5.3 Preparation of cost sheet, Costing of yarn, fabric and Garment; Cost reduction techniques. 5.4 General Information about maintenance, Preventive and breakdown maintenance of machinery, Maintenance in the Textile Industries. 5.5 Need and Importance of material handling, Different types of equipment used for materials handling. 5.6 **Concept of Industrial Safety and Safety procedure.** 5.7 Categories of accidents, means of Prevention of accidents, Causes and remedies of accidents in textile mills. 5.8 **Health hazards and Precautionary measures in textile mill.**	**CO5**

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: S2428602 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. Do internet survey of the plant layout, building construction for spinning and weaving mill and prepare a report.
2. Prepare power point presentation for understanding hank organization for different yarn counts.
3. Visit to any Textile manufacturing industry and prepare a report consisting of

   (a) Organization structure of the organization/Department.
   (b) Safety measures taken in organization.
   (c) Mechanism to handle the disputes.
   (d) Any specific observation you have noticed.
4. Prepare critical report on salient features of SEZ (Special Economic Zone) and textile cluster in your area.
5. Draw the complete plan layout of spinning mill with machinery dimension on drawing sheet.
6. Draw the complete plan layout of weaving unit with machinery dimension on drawing sheet.
7. Prepare the spinning organization plan for carded and combed yarn in spinning mill.
8. Prepare the spinning organization plan for blended polyester/ cotton (67:33) yarn in spinning mill.
9. Prepare the weaving plan for cotton shirting fabric on shuttleless weaving machines.
10. Prepare organization plan for ring spinning mill and preparatory departments based on ring spindle capacity and production of ring spun yarn (Carded/Combed/Blended).
11. Prepare organization plan for ring spinning mill and preparatory departments based on ring spindle capacity and production of ring spun yarn (Folded).
12. Prepare organization for rotor spinning mill and preparatory departments based on rotor spindle capacity and production of rotor spun yarn.
13. Calculate number of machines in weaving / weave plan – Preparation of organization for shuttle & based on number of weaving machines & production of different cloths.
14. Conduct a library/internet survey on labour compliments in spinning and weaving mills and prepare a report.
15. Prepare chart for optimum labour compliment in spinning and weaving mill.
16. List out the operative's duties of spinning preparatory machines, ring spinning and post spinning machines.
17. List out the operative's duties of weaver and jobber working on shuttleless weaving machine.
18. Prepare a operatives duty chart of beam gaiter, fitter, helper working on shuttleless weaving machine.
19. Calculations related to Break even analysis and Standard costing.
20. Prepare a chart on the safety measures observed in Textile Mills.
21. Conduct library/internet survey for health hazards in spinning and weaving mills and prepare a report.

b. Micro Projects:

1. Prepare a report on the Management Problems of Indian Textile Industry and their remedies.
2. Prepare a power point presentation of various documents and permissions required for site selection and building construction of Textile mill.
3. Prepare a plant and machinery layout for (i) Spinning mill, (ii) Weaving mill and (iii) Knitting mill taking into consideration the aspects of a good plant layout.
4. Visit any spinning unit and collect the data for number of machine, make of machine in various departments and prepare the data sheet regarding speed, production rates, draft, twist, % of waste collected at various departments for different counts of yarn spun.
5. Prepare a weave plan for any particular sort for specific production capacity and also calculate the

number of machines required for weaving preparatory.

6. Visit a Composite Textile mill and collect a data on the actual labour complement of each department in the mill and prepare a report by comparing it with standard labour complement.
7. Prepare cost sheet of specified yarn, fabric and garment.
8. (i) Visit a Composite Textile mill and collect data on various materials handling method/equipment and prepare a chart for the same.

   (ii) Visit a Composite Textile mill and collect a data on the safety and health hazards in the mill and prepare a report.
9. Prepare case study of Safety measures followed in different types of organization.

c. Other Activities:

1. Seminar Topics:
   - Duties of Supervisor/Shift In-charge spinning/Weaving Mill.
   - Cost-Volume-Profit (CVP) analysis.
   - Organizational Structure of Textile Industry
   - Profit and Budgetary Control in Textile.
   - **Fire prevention and control systems.**
   - Employee motivation in Textile Industry.

2. Visits: Visit nearby any two/ three spinning/weaving, processing unit/Composite mills with modern facilities. Prepare report of visit with special comments of advanced machines and cost.

3. Self-Learning Topics:
   - Project planning for Spinning/Weaving/Processing unit/ Composite mills.
   - Safety measures observed in Textile Mills.
   - lay outs of (i) Ring Spinning mills, (ii) Rotor spinning mill, (iii) Yarn dyeing unit, (iv) Sizing mill, (v) Weaving mill (Loom shed), (vi) Fabric dyeing and finishing unit, (vii) Knitting mill.
   - Balancing machines in Textile industry.
   - Procedure of Work study, Motion study and Snap study.
   - Trade union and collective bargaining.

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	16%	16%	20%	-	-	-	-
CO-2	21%	21%	20%	25%	25%	-	-
CO-3	21%	21%	20%	25%	25%	-	-
CO-4	21%	21%	20%	25%	25%	-	-
CO-5	21%	21%	20%	25%	25%	-	-
Total Marks	**30**	**70**	**20**	**20**	**10**	-	-
			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 percentages given are approximate.
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment:

Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Introduction to Textile Management	08	CO1	10	3	3	4
Unit-2.0 Site Selection, Plant and Machinery Layout for Textile mills	10	CO2	15	4	6	5
Unit-3.0 Organization of Textile Mills	10	CO3	15	4	5	6
Unit-4.0 Labour Complement in Textile Mills	10	CO4	15	4	5	6
Unit-5.0 Costing, Maintenance, Material handling and Safety in Textile Industry	10	CO5	15	5	5	5
Total Marks	**48**	--	**70**	**20**	**24**	**26**

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

O) Suggested Assessment Table for Laboratory (Practical): (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, 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: (Not Applicable)

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Management of Systems	A. S. Chauhan	Jain Brothers, New Delhi, 2001. ISBN: 81-8321-06-03
2.	Principles of Management	Tripathi P C and Reddy P N	MCgraw Hill Education, 2012 ISBN-10: 0-07-133333-9, 13: 978-0-07-33333-7

3.	Textile Project Management	A. Ormerod	The Textile Institute, 1992; ISBN: 10-1870812387, 13-978-1870812382
4.	Modern Textile Management	J.B. Rattan	Abhishek Publications, India, 2017 ISBN-10 : 8182478804; 13 : 978-8182478800
5.	Textile Mill Management: Theory and Practice	Naresh Grover	Random publication. 2016. ISBN 10:9351118738, 13:978-9351118732
6.	Textile Management Guidelines for Technician	Arvind Kumar Upadhyay	Woodhead Publishing India Pvt. Ltd.; 2022 ISBN:10-8195761828; 13- 978-8195761821
7.	Management of Textile Industry	Dudeja V. D.	Textile Trade Press, Ahmedabad, 1981. ISBN: 819010330X, 9788190103305
8.	Training and development of technical staff in the textile industry	B. Purushothama	Woodhead Publishing India Pvt. Ltd., 2012, ISBN: 978-9-38030-821-0; 978-0-85709-581-7
9.	Humidification and Ventilation Management in Textile Industry	Purushothama B	Woodhead Publishing, 2010 ISBN: 8190800124, 9788190800129
10.	A Practical Guide to Quality Management in Spinning	Purushothama B	Woodhead Publication, 2011 ISBN: 13-978-0857090065
11.	Cost Accounting in Textile Mills	Bhave P.V. and Srinivasan V.	ATRIRA, Ahmedabad, 1974
12.	Weaving – Machine, Mechanism and Management	Talukdar M K, Srirammulu P K and Ajgaokar D B	Mahajan Publisher Private Ltd., Ahmedabad, India, 1998
13.	Project, Planning Analysis, Selection Implementation & Review	Prasanna Chandra	Tata McGraw Hill Publishing Co. Ltd, 2019 ISBN-10- 8194113830; 3- 978-8194113836
14.	Material Handling Systems: Designing for Safety and Health	Reese Charles	Taylor and Francis, New York ISBN: 1-56032-868-1

(b) Online Educational Resources:

1. http://www.yourarticlelibrary.com/industries/location-selection/factors-affecting-site-location-of-an-industrial-unit-i-primary-and-ii-secondary-site-selection/26167
2. https://www.businessmanagementideas.com/industrial-engineering/selection-of-the-site-for-an-industrial-plant-site-selection-industrial-engineering/11878
3. https://facta.junis.ni.ac.rs/aace/aace200601/aace200601-01.pdf
4. https://en.wikipedia.org/wiki/special_economic_zone
5. https://dcmsme.gov.in/mse-cdprog.htm
6. https://www.cottonyarnmarket.net/OASMTP/HUMIDIFICATION%20IN%20TEXTILE%20MILL.pdf
7. https://www.businessmanagementideas.com/industries/plant-layout/5-main-types-of-plant-layout-industries/9239
8. https://nptel.ac.incourses/Webcourse-contents/IIT-ROORKEE/INDUSTRIAL-ENGINEERING/part2/facility%20design/lecture4.htm
9. https://www.textileschool.com/173/yarn-spinning-formulas/
10. https://textilelearner.blogspot.com/2018/03/formula-spin-plan-weave-plan.html
11. https://textilecalculation.blogspot.com/2015/12/how-to-calculate-warping-plan-in-weaving.html
12. https://nptel.ac.im/courses/112107142/24
13. http://nptel.ac.in/courses/112107142/part2/material%20handling/lecture1.htm

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. Industrial Engineering and Management, O P Khanna; Dhanpat Rai and Sons, Delhi; ISBN-10: 818992835X, ISBN-13: 978-8189928353
2. Textile technocracy : human relations in factories by Darab B. Unwalla, Popular Book Depot, Bombay, 1958.
3. Textile Machine Drawing, Woodhouse, Thomas, Blackie and sons Ltd London, 1921.
4. Textile Mill Planning & Organization by Varma D.S; Metropolitan Book Co. Ltd. Publ., Delhi, 1964.
5. Practical Cotton Mill Management in India by B.S. Benjamin, Culcutta Phototype Co., Culcutta
6. The Textiles by Madan Gaur, PPSI, Bombay, 1977
7. Costing in Cotton Textile Industry by H. K. Verma
8. Factory act and Industrial Safety.
9. Norms for Process Parameters, Productivity etc. ATIRA, BTRA, SITRA, NITRA.

******

A) Course Code : 2428603A (T2428603A/S2428603A)

B) Course Title : Advanced Yarn and Fabric Manufacturing

C) Pre- requisite Course(s) : Textile Fibres, Man-made Fibre Technology, Yarn Manufacture-I, Yarn Manufacture-II, Fabric Manufacture-I, Fabric Manufacture-II

D) Rationale :

"Advanced Yarn and Fabric Manufacturing" course is being offered as an elective for those students who are interested in enhancing their knowledge and skill in state-of-the-art machinery and technologies utilized in yarn spinning and fabric manufacturing, including advanced looms, spinning machines, and automated production systems. This course ensures that students gain specialized expertise and a profound understanding of modern textile production methods, preparing them to contribute effectively to the textile industry's dynamic landscape. It enhances their competitiveness in the global textile industry, aligning with technological advancements in the field.

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

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

CO-1 Select Friction spinning or Air jet spinning for production of the given yarn based on their advantage and limitation.

CO-2 Select the yarn produced by relevant advanced yarn manufacturing process for a given application.

CO-3 Suggest the most suitable shuttle less weaving method for a given application with optimizing production efficiency.

CO-4 Recommend the relevant fabric manufacturing method by assessing the advantages and challenges associated with modern loom technology.

CO-5 Apply effective quality control systems in yarn and fabric manufacturing, ensuring compliance with industry standards.

F) Suggested Course Articulation Matrix (CAM):

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

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				
2428603A	Advanced Yarn and Fabric Manufacturing	02	01	-	02	05	04

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:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
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2428603A	Advanced Yarn and Fabric Manufacturing	30	70	20	30	-	-	150

Legend:

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

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

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: T2428603A

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.1a Explain the principle of yarn formation in friction spinning and air-jet spinning. *TSO.1b* Compare the structure and properties of yarn produced by friction spinning and air-jet spinning with other spun yarn. *TSO.1c* Describe advantages and limitations of friction spinning and air-jet spinning.	**Unit-1.0 Friction Spinning and Air-jet Spinning** 1.1 Yarn formation principle on friction-spinning machines 1.2 Friction-spun yarn structure, properties and applications 1.3 Advantages and limitations of friction spinning 1.4 Basic air-jet spinning methods 1.5 Structure, properties and applications of air-jet spun yarns 1.6 Advantages and limitations of air-jet spinning	**CO1**
TSO 2a. Explain the principle of yarn formation in given spinning system. *TSO 2b.* Distinguish between two given spinning process. *TSO 2c.* Compare the properties of the yarn manufactured by two given system. *TSO 2d.* Select the relevant process for yarn formation as per given requirement.	**Unit-2.0 Other Advance yarn manufacturing Technology** 2.1 Compact spinning technology: Yarn formation principle and process, Yarn properties and application 2.2 Yarn formation principle and process of following system: Sirospun, Solospun, Hollow spindle spinning, Self-twist spinning, Wrap Spinning, PLYFIL spinning system 2.3 Comparison of yarn properties manufactured using different spinning technology	**CO2**
TSO 3a. Describe the weft insertion mechanism of a given shuttle-less loom. *TSO 3b.* Explain the working principle of the given shuttle-less loom. *TSO 3c.* Compare the features of the two-given shuttle-less looms. *TSO 3d.* Suggest the suitable shuttle less loom for the given fabric production.	**Unit-3.0 Shuttle-less weaving** 3.1 Rapier weaving, Classification of Rapier weaving machine, weft insertion mechanism, Salient features of modern rapier loom 3.2 Projective weaving, Basic principle, sequence of weft insertion, Torsion bar picking mechanism, Salient features of modern Projectile loom 3.3 Air jet weaving, Basic principle, sequence of weft insertion, weft accumulator, air nozzle and its design, factor effecting pneumatic weft propulsion. Salient features of modern air jet loom 3.4 Water jet weaving, Basic principle, sequence of weft insertion, nozzle design, quality of yarn required, quality of water, Salient features of modern water jet loom 3.5 Merits and demerits of above weaving technologies	**CO3**
TSO 4a. Explain the working principle of given modern loom. *TSO 4b.* Describe the shedding operation in multiphase weaving.	**Unit-4.0 Modern Loom Technology** 4.1 Multiphase weaving, basic concept, shedding operation in warp way and weft way multi-phase loom, advantage and disadvantage of multi-phase waving process	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 4c. Compare the shedding mechanism of modern looms with conventional shuttle loom. *TSO 4d.* Identify different multiaxial and breaded fabric.	4.2 Circular loom: yarn path and weft insertion in circular loom 4.3 Multi axial Weaving and its application. 4.4 Introduction to breaded structure and Carpet weaving	
TSO 5a. Select the relevant quality parameters to be followed during given yarn manufacturing. **TSO 5b. Suggest the required modification to improve the quality of yarn being produced.** TSO 5c. List down different techniques followed during fabric production. **TSO 5d. Suggest required modification in the manufacturing process to improve the fabric quality.**	**Unit-5.0 Quality Control and Optimization in Manufacturing** 5.1 Process Control in Yarn Manufacturing 5.2 Quality control methodologies in yarn spinning 5.3 Parameters affecting yarn quality and methods for optimization 5.4 **Fabric Production Control and Optimization** 5.5 Techniques for controlling fabric quality during manufacturing 5.6 **Process optimization for higher production efficiency**	**CO5**

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: S2428603A 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. Conduct a library survey and prepare a chart for various types of Spinning system used for yarn manufacturing.
2. Prepare a report highlighting the advantages, limitations, and quality aspects of new yarn spinning system.
3. Prepare a report on the impact of different weaving machines on production efficiency and fabric quality.
4. Propose optimization techniques to enhance yarn quality parameters such as evenness and strength.
5. Prepare a fabric production control plan for air-jet weaving machines for monitoring and controlling fabric quality during the manufacturing process.

a. Micro Projects:

1. Compare the productivity and yarn quality of the yarn produced by different spinning machines available in the laboratory.
2. Create a power point presentation on working of shuttle less looms.
3. Collect fabric samples produced by different shuttle-lees looms, analyze the defects and prepare a report on fabric defects highlighting their possible reasons.
4. Study the effect of spinning type on the absorbency of the yarn and prepare a report.
5. Collect the data of production and efficiency of various fabric produced on different looms and prepare a comparative report.

b. Other Activities:

i. Seminar Topics:
- Innovations in yarn spinning Technology
- Automation and Robotics in Loom Technology
- Quality Control Measures in Yarn and Fabric Production
- Artificial Intelligence and Smart Textiles
- Quality Control Measures in Yarn and Fabric Production
- Textile Waste Management and Recycling

ii. Visits: Visit nearby Textile/Garment industry, which produces smart textile products and Prepare report of visit with special comments on various process used, material used, machinery used, batch production/mass production and cost of final product.

iii. Self-Learning Topics:
- Role of Advanced Yarn and Fabric in the Global Textile Market
- Innovative Jacquard Weaving Patterns
- 3-D woven fabrics
- Application of multi axial fabrics
- Eco-friendly approaches and sustainable practices in fabric weaving

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%	20%	20%	20%	-	-
CO-2	20%	20%	20%	20%	20%	-	-
CO-3	20%	20%	20%	20%	20%	-	-
CO-4	20%	20%	20%	20%	20%	-	-
CO-5	20%	20%	20%	20%	20%	-	-
Total Marks	**30**	**70**	**20**	**20**	**10**	**-**	**-**
			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 percentages 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 Friction Spinning and Air-jet Spinning	10	CO1	14	4	5	5
Unit-2.0 Other Advance yarn manufacturing Technology	9	CO2	14	4	5	5
Unit-3.0 Shuttle-less weaving	10	CO3	14	4	5	5
Unit-4.0 Modern Loom Technology	10	CO4	14	4	5	5
Unit-5.0 Quality Control and Optimization in Manufacturing	9	CO5	14	4	5	5
Total	**48**	**-**	**70**	**20**	**25**	**25**

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

O) Suggested Assessment Table for Laboratory (Practical): (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.	Advances in Yarn Spinning Technology	C A Lawrence	Woodhead Publishing, 2010, ISBN: 978-1845694449
2.	New Spinning Systems	W Klein	The Textile institute, Manchester ISBN : 1870812557
3.	Process Control and Yarn Quality in Spinning	G. Thilagavathi (Editor), T. Karthik (Editor)	WPI Publishing, 2015 ISBN: 978-9380308357
4.	Principle Of Weaving	R. Marks & A.T.S. Robbinson	The Textile Institute, Manchester, 1976 ISBN:0-900739258
5.	Weaving, Machines, Mechanisms, Management	M.K. Talukdar	Mahajan Publishers Ahmedabad,1998 ISBN: 8185401160
6.	Advanced Weaving Technology	Francois Boussu, Yordan Kyosev	Springer International Publishing, 2022

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
7.	Process Control in Textile Manufacturing	Abhijit Majumdar (Editor), Apurba Das (Editor), R Alagirusamy (Editor), V K Kothari (Editor)	Woodhead Publishing Limited ISBN: 978-0857090270
8.	Process Management in Spinning	R. Senthil Kumar	CRC Press, 20 19 ISBN : 978-0367378332

(b) Online Educational Resources:

1. https://archive.nptel.ac.in/courses/116/102/116102055/
2. https://archive.nptel.ac.in/courses/116/102/116102059/
3. https://textilelearner.net/modern-and-new-spinning-technologies/
4. https://archive.nptel.ac.in/courses/116/102/116102017/
5. https://www.textileschool.com/360/types-of-fabric-weaving-looms/
6. http://www.columbia.edu/cu/computinghistory/jacquard.html
7. https://dynamiclooms.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.

(c) Others:

1. New Spinning Systems; Gowda, R.V. Mahendra, NCUTE Publications, 2003, IIT Delhi
2. Recent developments in rapier weaving machines in textiles, S Maity, K Singha, M Singha - American Journal of Systems Science, 2012
3. A Practical Guide to Quality Management in Spinning; B. Purushothama, Woodhead Publishing Ltd, ISBN: 978-0857090065
4. Textile Research Journal, Sage Publications Mumbai
5. Process Control in Textile Manufacturing; Abhijit Majumdar (Editor), Apurba Das (Editor), R Alagirusamy (Editor), V K Kothari (Editor); Woodhead Publishing ISBN 978-0857090270.

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A) Course Code : **2428603B (T2428603B/S2428603B)**

B) Course Title : Sericulture and Silk Technology

C) Pre- requisite Course(s) : Textile Fibres,

D) Rationale :

Silk is a high-value textile material with a long history of use in luxury fashion, home textiles, and industrial applications. It finds applications in a wide range of textiles, from fine clothing and accessories to technical textiles, such as medical sutures. Moreover, Sericulture, when managed sustainably, can be an environmentally friendly and renewable source of Silk fiber. "Sericulture and Silk Technology" is being offered as an elective for those students who are interested in enhancing their knowledge and skill in this field. This course equips students with a unique and specialized skill set that can lead to diverse career opportunities in the textile industry. It fosters an appreciation for the role of sericulture in the global textile supply chain and encourages sustainable practices in fiber production and processing, aligning with modern textile industry trends and the need for environmentally responsible manufacturing.

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

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

CO-1 Comprehend sericulture process and growth of silk industry in India and abroad.

CO-2 Assess the quality of cocoon used in Silk fabric production.

CO-3 Suggest relevant reeling machine and process to be used based on the given production requirement.

CO-4 Apply the knowledge for weaving and processing of Silk in Silk fabric production.

CO-5 Evaluate the applicability and effectiveness of various schemes in facilitating sericulture-based entrepreneurship and rural economic upliftment.

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/ Develop-ment 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	1	-	-	1	1		
CO-3	3	3	3	1	-	1	1		
CO-4	3	2	2	1	2	1	1		
CO-5	3	2	3	1	2	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:

Course Code	Course Title	Scheme of Studies (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (SW+ SL)	Total Hours (CI+LI+SW+SL)	Total Credits(C)
		L	T				
2428603B	Sericulture and Silk Technology	02	01	-	02	05	04

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:

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)	
2428603B	Sericulture and Silk Technology	30	70	20	30	-	-	150

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.

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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: T2428603B

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain importance of Sericulture industry in Textile *TSO 1b.* Describe different process involved in Sericulture. *TSO 1c.* Differentiate between different types of silk. *TSO 1d.* Suggest different methods to improve quality of silk worm rearing. *TSO 1e.* Identify different grade of silk. *TSO 1f.* Describe the employment potential inherent in various aspects of sericulture activities.	**Unit-1.0 Sericulture** 1.1 Sericulture and silk industry: Historical Significance of Sericulture, Status of sericulture and silk industry in India and abroad, Economical Importance of Sericulture 1.2 Sericulture Process: Mulberry cultivation, Types of Mulberry, Silkworm rearing and cocoon formation, Environmental conditions for silkworm rearing, Cocoon harvesting and grading 1.3 Rearing of Tasar and Eri silk worm 1.4 Diseases and pests of silk worm and their control by different methods, Factors influencing the silkworm Rearing, Recent development in rearing 1.5 Quality Control in Sericulture: Factors influencing silk quality, Silk fiber identification and grading, Techniques for sericulture quality assessment 1.6 Entrepreneurial opportunity in Sericulture	CO-1
TSO 2a. Classify the cocoons. *TSO 2b.* Describe various methods used for sorting, testing, drying and storage of cocoons. *TSO 2c.* Suggest relevant method for cooking of cocoons. *TSO 2d.* Identify non-mulberry cocoons.	**Unit-2.0 Cocoons** 2.1 Different types of cocoons, Physical and commercial characteristics of cocoons. 2.2 Sorting of cocoons, Cocoon testing, Storage of cocoons 2.3 Stifling of cocoons, Drying of cocoons. 2.4 Cooking of cocoons – Various methods employed. 2.5 Brushing/Deflossing of cocoons. 2.6 Non-mulberry cocoons: Tassar, Muga, Eri. 2.7 Application of waste cocoon : spun silk	**CO2**
TSO 3a. Explain the process of reeling. TSO 3b. Differentiate between two given type of silk reeling machine. TSO 3c. Describe the process of testing and grading of raw silk.	**Unit-3.0 Reeling and Throwing** 3.1 Silk reeling, System of reeling 3.2 Types of silk reeling machines: country charka; cottage basin; multi-end reeling;	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 3d. Describe the construction and working of given doubling machine. TSO 3e. Identify the given type of silk yarn based on twist levels.	and automatic reeling; Merits and demerits of these reeling machines, 3.3 Raw silk Testing and Grading, Packing of raw silk 3.4 Silk throwing, winding, doubling, rewinding and twisting 3.5 Throwing machinery: twisting frames, doubling machines 3.6 Types of Silk yarn based on number of plies and different level of twist	
TSO4a. Identify the different preparatory process used in silk weaving. *TSO4b.* Suggest modification required in the loom for Silk weaving. *TSO4c.* Suggest relevant Silk fabric for given application. *TSO4d.* Differentiate between given type of degumming method. *TSO4e*. Select the suitable dye and dying process of silk for given application. *TSO4f*. Describe advantages and disadvantages of finishing of silk.	**Unit-4.0 Silk Weaving and Processing** 4.1 Preparatory process for silk weaving 4.2 Different machinery employed in small scale and organized sections. 4.3 Silk Weaving – Handloom and Power loom Weaving, Special features of Silk looms, Modifications required to weave Silk fabrics. 4.4 Types of silk fabrics and their applications 4.5 Degumming of Silk, Methods of degumming, Weighting of silk 4.6 Dyeing of silk with Acid, Basic, Reactive, direct and natural dyes 4.7 Printing and Finishing of Silk	**CO4**
TSO 5a. Estimate the costs associated with different sericulture activities. TSO 5b. Explain various financial schemes and their roles in promoting sericulture and rural development. TSO 5c. Recognize the role of different organizations involved in sericulture development. TSO 5d. Enlist the potential benefits and challenges associated with international trade in silk. **TSO 5e. Enumerate the significance of eco-friendly sericulture practices and their impact on sustainability.**	**Unit-5.0 Sericulture and Rural Economy** 5.1 Employment generation through Sericulture, cost estimation for different sericulture activity 5.2 Financial Schemes to promote Sericulture: IRDP, TRYSEM, DWCRA, NREP, SGRY, SGSY 5.3 Integration of different organizations for development of sericulture such as Scientific Institutions (Research and Development, Government Departments, Extension Functionaries, NGO's, Universities) 5.4 Opportunities for cross-border collaboration and trade in silk products **5.5 Importance of eco-friendly sericulture, Sustainable sericulture techniques and waste management.**	**CO5**

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: S2428603B Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

i. Prepare a report on status of sericulture in a various region of country.
ii. Collect the information and prepare a report regarding quality control methods used in rearing of Silk worm.
iii. Create a presentation summarizing various schemes to promote Sericulture in India.
iv. Collect the detail specifications of different type of reeling machine available and prepare power point presentation on the same.
v. Prepare a report on different weaving machine used for silk weaving.

b. Micro Projects:

1. Collect silk cocoons from different sources and evaluate them based on size, shape, color, and quality.
2. Design a sustainable sericulture model incorporating eco-friendly practices such as organic farming, waste management, or natural pest control methods.
3. Conduct a market study to evaluate the demand for different types of silk products in the local market and prepare a report.
4. Conduct a comparative study of Dying of silk fabric using 3 different variety of dyes.
5. Prepare a report on the comparison of technical parameters such as tensile strength, uniformity, and appearance of different silk yarn samples collected from different sources or manufacturers.

c. Other Activities:

i. Seminar Topics:
- Various government schemes for promotion of Sericulture in Bihar
- Methods of Cocoon Shorting
- Advancement in reeling technology.
- Modern looms for silk filament weaving.
- Planning of Silkworm Rearing Plant

ii. Surveys:
- Carry out a market survey for availability of different types of silk fabric for clothing application.
- Carry out a survey a market for availability of different types of silk yarns used for manufacturing Silk fabric and Sarees.

iii. Visits:
- Visit a sericulture farm and interact with farmers. Study the farming practices, mulberry cultivation, silkworm rearing methods, and cocoon harvesting techniques. Prepare a report analyzing the farm's operations and identifying areas for improvement.
- Visit a nearby Silk industry and prepare a report on the weaving machine and other equipment used to prepare the silk fabric.

iv. Self-Learning Topics:
- Life Cycle of Silkworm
- Sericulture Economics and Marketing
- Silk Cocoon Characteristics
- Variations in Silk Reeling Process
- Sericulture Policies and Government Schemes
- International Silk Trade and Global Market

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 (SWA)			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	21%	21%	20%	20%	20%	-	-
CO-4	16%	16%	20%	20%	20%	-	-
CO-3	21%	21%	20%	20%	20%	-	-
CO-4	21%	21%	20%	20%	20%	-	-
CO-5	21%	21%	20%	20%	20%	-	-
Total Marks	**30**	**70**	**20**	**20**	**10**	-	**-**
			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 percentages 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 Sericulture	10	CO1	15	4	6	5
Unit – 2.0 Cocoons	8	CO4	10	4	3	3
Unit- 3.0 Reeling and Throwing	10	CO3	15	4	6	5
Unit -4.0 Silk Weaving and Processing	10	CO4	15	4	5	6
Unit – 5.0 Sericulture and Rural Economy	10	CO5	15	4	6	5
Total Marks	**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): (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.	An Introduction to Sericulture	GANGA G.	Oxford & Ibh Publishing, ISBN: 978-8120411791
2.	An Introduction to Sericulture	M. Madan Mohan Rao	Bsp Books, ISBN: 978-9387593978
3.	Silk: Processing, Properties and Applications	K. Murugesh Babu	Woodhead Publishing, ISBN: 978-0081025406
4.	Advances in Silk Science and Technology	Arindam Basu	Woodhead Publishing Ltd., ISBN: 978-1782423119
5.	The Complete Book on Textile Processing and Silk Reeling Technology	H. Panda	Asia Pacific Business Press Inc., ISBN : 978-8178331355
6.	Wild Silk Technology	T. V. Kavane, R. K. & Sathe	Daya Publishing House, ISBN: 978-8170357124
7.	Handbook Of Silk Technology	Tammanna N.Sonwalkar	New age publishers, ISBN: 978-8122404951
8.	Silk Dyeing, Printing & finishing	Hurst G. H.	Read Books, ISBN: 978-1446524916

(b) Online Educational Resources:

1. https://onlinecourses.swayam2.ac.in/cec20_bt08/preview
2. https://onlinecourses.swayam2.ac.in/cec19_bt05/preview
3. https://cstri.res.in/index.php/related-links/
4. https://www.shiksha.com/engineering/silk-technology-chp
5. https://www.fao.org/3/x2099e/x2099e02.htm
6. http://www.csrtimys.res.in/sites/default/files/ebooks/2014-1.pdf
7. https://silks.csb.gov.in/datia/wp-content/themes/Common_District/datia/CSTRI%20Training%20Calender%20-2013-14.html

(c) Others:

1. FAO manuals, on sericulture, volume 1-IV, FAO Publication
2. Silk Weaving Compiled by Zhejiang, Silk Engineering Institute
3. Sericulture Training Manual, FAO Publication
4. Silk Reeling and Testing Manual, FAO Publication
5. Silk Dyeing, Printing & finishing by Guljarani M L IIT, New Delhi (1986)

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A) Course Code **: 2428603C (T2428603C/S2428603C)**

B) Course Title **:** Smart Textile

C) Pre- requisite Course(s) **:** Textile Fibres, Man-made Fibre Technology, Yarn Manufacture-I, Yarn Manufacture-II, Fabric Manufacture-I, Fabric Manufacture-II

D) Rationale **:**

With the inventions of Smart materials, electronic chips, computers, IOT, the discovery and complete mapping of the human genome, and many more, revolutionary changes have been occurring at an unprecedented rate in many fields of science and technology. This has also brought tremendous advances in the textile and clothing industry. This course introduces students to an evolving field within textile engineering that amalgamates traditional textile materials with advanced technologies, enabling the development of textiles with interactive and adaptive functionalities. This course is aim to equips students with specialized knowledge, fostering innovation, problem-solving skills, and preparing them to navigate the ever-evolving and technology-driven textile industry.

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** Identify the niche application area of smart textile to be explored for future development.
- **CO-2** Select smart polymeric material to be used for a given application.
- **CO-3** Suggest relevant sensors, actuators, power supply system and their combination for manufacturing of smart textile for a given scenario.
- **CO-4** Select appropriate manufacturing and integration techniques for fabricating smart textile for a given application.
- **CO-5** Apply knowledge in textile engineering and electronics to design and develop smart textile systems with specific functionalities, considering user needs and technological constraints.

F) Suggested Course Articulation Matrix (CAM):

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

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				
2428603C	Smart Textile	02	01	-	02	05	04

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:

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)	
2428603C	Smart Textile	30	70	20	30	-	-	150

Legend:

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

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

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: T2428603C

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain the scope, importance and uses of Smart textile. *TSO 1b.* Describe the journey of development of smart textile. *TSO 1c.* Differentiate between passive smart and active smart textile. *TSO 1d.* Suggest the relevant application area for smart textile.	**Unit-1.0 Smart Technology for Textiles and Clothing** 1.1 Historical development, Smart textile, need of smart textile, scope, importance and uses of Smart textile. 1.2 Classification of Smart textile. 1.3 Development of smart technology for textiles and clothing – sensors/actuators, for signal transmission, processing and controls. 1.4 Smart and Intelligent Textiles: Passive and Active functionality, Difference between passive smart and active smart textile. 1.5 Research and development in new products-niche application. 1.6 Application and market for smart textile.	**CO1**
TSO 2a. List down various smart polymeric material. *TSO 2b.* Explain the functionality of phase change material used in Textile. *TSO 2c.* Select electrically active polymers for smart textile application *TSO 2d.* Describe use of carbon nanotubes in smart textiles.	**Unit-2.0 Smart Polymeric Materials** 2.1 Piezoelectric fibres, phase-change materials, and shape memory fibres 2.2 Phase change technology, PCMs in textiles, textile treatment with PCM microcapsules, thermal performance, test methods, applications, 2.3 Polymeric membranes: PVA and PAAc network, Polymers prepared by plasma and radiation grafting. 2.4 Electrically active polymer materials: conductive polymers, conductive yarns, Silver coated textile 2.5 Carbon nanotubes 2.6 Future trends	**CO2**
TSO 3a. Describe data stream categories for smart textile. *TSO 3b.* Explain the functionality of given sensor in smart textile application. *TSO 3c.* Describe working principle of various actuators used for smart textile. *TSO 3d.* Select appropriate power supply source for integration. *TSO 3e.* Design appropriate model by integrating relevant sensors, actuators, power supply sources for a particular application.	**Unit-3.0 Sensors, Actuators and Computing Systems for Smart Textiles** 3.1 Data Stream Categories 3.2 Sensors in Textile 3.3 Actuators in textiles 3.4 Power supply sources 3.5 Networks 3.6 Application examples	**CO3**
TSO 4a. Select relevant manufacturing process for integration of smart materials in textile. *TSO 4b.* Explain the given printing technique for printing circuit boards on textile for a given application. *TSO 4c.* Explain given method of integration of textile and electronics.	**Unit-4.0 Production Technologies for Smart Textile** 4.1 Integration of smart materials in Textile: Knitting, weaving, spacing Textile, Embroidering 4.2 Printed circuit boards on textiles, Screen and Stencil printing, Inkjet Printing, The CREATIF printing, Curing	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 4d. Describe the method to improve the washability of smart textile.	4.3 Incorporating sensors into smart textiles through the use of optical fibres 4.4 Contacting methods between Textile and Electronics: Manual soldering, laser soldering 4.5 Coating to improve washability of integrated part	
TSO 5a. Explain the use of smart textile in the given application area. *TSO 5b.* Differentiate between the functionality of smart textile used for two given area. *TSO 5c.* Suggest suitable application area for the given smart textile material. *TSO 5d.* Differentiate between resistive and capacitive touchpads. *TSO 5e.* Describe the application of software platform for smart textile material.	**Unit-5.0 Application Areas of Smart Textile and Examples** 5.1 Smart Textile in Medical and Health Care 5.2 Smart textile for personal protection equipment 5.3 Smart textile in construction and geotechnical applications 5.4 Application of Smart textile in various field of Technical Textile 5.5 Resistive Touchpads/Sensors: Sensomative, Fabri Touch 5.6 Capacitive Touchpads and Sensors : Amotape Pressure Sensor, Google Jacquard 5.7 GeniusTex Smart Textiles platform	**CO5**

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: S2428603C 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. Conduct a library survey and prepare a chart for various types of smart textile developed with their functionality.
2. Prepare a presentation highlighting disruptive technologies, potential applications, and their impact on the textile industry.
3. Prepare a report on different types of sensors and actuators used in the smart textile.
4. Select a specific industry (e.g., healthcare, automotive, fashion) and conduct a case study on the application of smart textiles within that industry. Analyze the challenges, benefits, and future prospects of smart textile integration.
5. Prepare a report on application of smart textile in various sectors.

b. Micro Projects:

1. Design and fabricate a fabric-based prototype (e.g., a pressure-sensitive mat or temperature monitoring band) for healthcare applications.
2. Develop a fabric panel with integrated sensors and actuators to detect touch or gestures.
3. Develop conductive textile samples using techniques like screen printing or coating with conductive materials (e.g., conductive ink). Test their conductivity and durability.
4. Create a sports attire prototype with sensors to monitor body movements and provide feedback on posture or performance.
5. Fabricate a textile sample using thermochromic or phase change materials to regulate temperature.

6. Design and produce a fashion item (e.g., a bag or hat) with embedded LEDs or other smart features. Create a prototype that showcases both aesthetics and functionality.

c. Other Activities:

1. Seminar Topics:
    - Nanotechnology in Smart Textiles
    - Invisible clothing using cloaking material
    - Wearable Technology and Health Monitoring
    - Smart Textiles in Fashion Industry
    - Artificial Intelligence and Smart Textiles
    - Smart Textiles for Military and Defense
    - Innovative Applications of Smart Textiles in Sports
    - Future Trends and Emerging Technologies in Smart Textiles

2. Visits: Visit nearby Textile/Garment industry, which produces smart textile products and Prepare report of visit with special comments on various process used, material used, machinery used, batch production/mass production and cost of final product.

3. Self-Learning Topics:
    - Sustainable Innovations in Smart Textiles
    - Internet of Things (IoT) in Textiles
    - Energy Harvesting Textiles
    - Challenges and Opportunities in Commercializing Smart Textiles
    - Smart Textile Sensors for Environmental Monitoring
    - Human-Machine Interaction through Smart Textiles

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	18%	18%	20%	20%	20%	-	-
CO-2	18%	18%	20%	20%	20%	-	-
CO-3	20%	20%	20%	20%	20%	-	-
CO-4	22%	22%	20%	20%	20%	-	-
CO-5	22%	22%	20%	20%	20%	-	-
Total Marks	**30**	**70**	**20**	**20**	**10**	**-**	**-**
			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 percentages 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 Smart Technology for Textiles and Clothing	8	CO1	12	4	4	4
Unit-2.0 Smart Polymeric Materials	8	CO2	12	4	4	4
Unit-3.0 Sensors, Actuators and Computing Systems for Smart Textiles	10	CO3	14	4	5	5
Unit-4.0 Production Technologies for Smart Textile	11	CO4	16	4	5	7
Unit-5.0 Application Areas of Smart Textile and Examples	11	CO5	16	4	5	7
Total	**48**	**-**	**70**	**20**	**23**	**27**

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): (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.	Smart Textiles: Fundamentals, Design, and Interaction	Stefan Schneegass (Editor), Oliver Amft (Editor)	Springer International Publishing, 2017, ISBN: 978-3319501239
2.	Overview of Materials, Sensor and Production Technologies for Industrial Smart Textiles.	Inga Gehrke , Vadim Tenner , Volker Lutz , David Schmelzeisen and Thomas Gries	MDPI, 2019 ISBN 978-3-03897-497-0
3.	Handbook of Smart Textiles	Xiaoming Tao	Springer Singapore, 2015 ISBN: 978-981-4451-44-4
4.	Smart Clothes and Wearable Technology	Jane McCann (Editor), David Bryson (Editor)	Woodhead Publishing, 2009 ISBN: 978-1845693572
5.	Smart Textiles: Wearable Nanotechnology	Yilmaz (Author), Nazire D. Yilmaz (Editor)	Wiley-Scrivener2018; ISBN: 978-1119460220

6.	Smart Textiles for Designers: Inventing the Future of Fabric	Rebeccah Pailes-Friedman	Laurence King Publishing, 2016 ISBN: 978-1780677323
7.	Smart fibres, fabrics and clothing	Xiaoming Tao	Woodhead Publishing Limited ISBN: 1 85573 546 6

(b) Online Educational Resources:

1. https://www.mdpi.com/books/mono/1191-smart-textiles-production
2. https://www.intechopen.com/chapters/73836
3. https://encyclopedia.pub/entry/3444
4. https://study.com/academy/lesson/smart-textiles-materials-products-examples.html
5. https://platform.ict-tex.eu/course/view.php?id=37

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. Advanced Functional Materials; N. Tasaltin, P. Sunday Nnamchi, and S. Saud, Eds., IntechOpen, 2020. doi: 10.5772/intechopen.
2. Smart and Functional Textiles; Adak, B.; Mukhopadhyay, S., De Gruyter: Berlin, Germany, 2023
3. Textile Research Journal, Sage Publications Mumbai
4. Fluorescence in Smart Textiles; Antonella Patti and Domenico Acierno, Encyclopedia 2023, 3(2), 665-676
5. Smart Textiles and Their Applications; Koncar, V., Ed.; Woodhead Publishing: Cambridge, UK, 2016; pp. 1–8. ISBN 9780081005835.
6. Smart fabric textiles: Recent advances and challenges; Luiz, H.; Júnior, O.; Neves, R.M.; Monticeli, F.M.; Agnol, L.D., Textiles 2022, 2, 582–605.

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A) Course Code **: 2428603D (T2428603D/S2428603D)**

B) Course Title **:** Non-woven & Knitting

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

D) Rationale **:**

Nonwoven fabrics can be used in a wide variety of applications like consumer products, industrial products and medical & healthcare products. During the past few years, the use of nonwoven has grown rapidly. The selection of the right material is very important while manufacturing nonwoven products. The selection of material depends upon the required function, nature and severity. Knitting is a comparatively faster and more economical process to convert yarn into fabric. Due to their unique features of stretchability, thermal properties, comfort and other favorable properties knitted fabrics are in good demand and are being used for undergarments, sports uniforms, summer and winter dresses etc. to a large extent. Knitting can produce a wide range of fabrics and products suitable for intimate wear to technical textiles including 3-D fabrics as well as medical textiles including human body implants. Therefore, the textile engineering students need to know all the relevant technical knowledge for the manufacturing of knitted fabrics and nonwovens and the machines used for manufacturing.

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

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

- **CO-1** Select the relevant web-forming process for the manufacturing of a given nonwoven.
- **CO-2** Select relevant web bonding methods to produce given non-woven fabrics.
- **CO-3** Identify the types of knitted fabric for various applications.
- **CO-4** Apply the knowledge of circular and flat knitting machines to knit the fabric.
- **CO-5** Apply the knowledge of the warp knitting machine to knit the fabric.

F) Suggested Course Articulation Matrix (CAM):

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

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

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

G) Teaching & Learning Scheme:

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				
2428603D	Non2woven & Knitting	03	01	-	02	05	04

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.

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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:

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)	
2428603D	Non-woven & Knitting	30	70	20	30	--	--	150

Legend:

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

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

TWA: Term work& Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, microprojects, 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 assignments, micro-projects, seminars 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 for internal as well as external assessment may vary as per the requirement of the respective course. For valid and reliable assessment, the internal faculty should prepare a 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 the attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020-related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: T2428603D

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Define the term non-woven. *TSO 1b.* Explain the sequence of the manufacturing process of the given non-woven fabrics. *TSO 1c.* Compare the features of the given non-woven structures and manufacturing process flow chart. *TSO 1d.* Draw a flow chart for the preparation of the different web formations. *TSO 1e.* Enlist different fibres and their properties used to produce non-woven fabrics. *TSO 1f.* Explain the different applications of non-woven fabrics. *TSO 1g.* Describe the characteristics of given non-woven fabric.	**Unit-1.0 Introduction to Nonwoven** 1.1 Introduction, Definition, Properties, Products, Market Overview and Growth Projections of Nonwoven 1.2 Classification of nonwovens: Dry-laid, Wet-laid, Spun-laid and Melt blown nonwovens 1.3 Manufacturing process: Web formation, Web bonding and Finishing treatments 1.4 Web forming process: Parallel laid webs, Cross laid webs, Random laid webs, Air laid webs 1.5 Raw materials and their properties used to produce nonwovens 1.6 Characteristics and applications of nonwovens	**CO1**
TSO 2a. Explain different web bonding methods. *TSO 2b.* Explain the properties required for the given application of non-woven fabric. *TSO 2c.* Describe the applications of Spun bond and Melt-blown non-woven fabrics. *TSO 2d.* Describe different finishes used for non-woven fabrics. *TSO 2e.* Describe the web bonding process for the given type of fibre.	**Unit-2.0 Web Bonding Methods and Finishing of Nonwovens** 2.1 Thermal bonding: Principle, Methods -Hot calendaring (Area bonding, Point bonding and Embossing), Belt calendaring, Through-air bonding, Ultrasonic bonding, Thermally bonded fabric structure, Applications of thermally bonded fabrics 2.2 Chemical (Adhesive) bonding: Bonding process, methods of binder application – Saturation, Foam, Spray, Print and Powder bonding, Applications of chemically bonded nonwovens 2.3 Spun bonding: Principles, process of manufacturing and physical properties of spun bonded fabrics 2.4 Mechanical bonding: Stitch bonding system, Needle punching technology and Hydroentanglement process technology 2.5 Needle punching: Basics of needle punching (needle loom) operation, up-punching, down punching, single needle board, multi-needle board, needle design and selection, needle reduction, needle type and specifications, punch density, applications of needle punched nonwovens 2.6 Spunlace nonwovens (Hydroentanglement): Process, Properties and Applications of spunlaced fabrics 2.7 Finishing of Nonwovens: Dry finishing, wet finishing and Chemical finishes	**CO2**
TSO 3a. Describe the fabric formation by knitting techniques with sketches. *TSO 3b.* Define the basic terms in knitting.	**Unit-3.0 Introduction to Knitting** 3.1 Introduction, knitting techniques, definitions of basic terms used in knitting - courses, wales, face	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 3c. Compare weaving and knitting. *TSO 3d.* Explain the advantages of knitted fabrics. *TSO 3e.* Compare warp knitting and weft knitting on given parameters.	loop, back loop, needle loop, sinker loop, technical face, technical back, stitch density, stitch length, course length, open loop, close loop 3.2 Properties of Knitted Fabrics, Comparison of weaving and knitting 3.3 Classification: Warp knitting and Weft knitting, comparison of warp knitting and weft knitting concerning process, structure and properties 3.4 Classification of knitting machines: Weft knitting machine and Warp knitting machine	
TSO 4a. Explain the basic structures of weft knitted fabric with sketches. *TSO 4b.* Compare different types of knitting needles with their merits and limitations. *TSO 4c.* Explain the functioning of elements of a given weft knitting machine with sketches. *TSO 4d.* Describe the knitting cycle for the given type of needle with sketches. *TSO 4e.* Describe the passage of yarn for the given type of knitting machine. *TSO 4f.* Explain the knitting process for the given type of knitting machine. *TSO 4g.* Distinguish the knitting process for the given knitting machines based on the principle of knitting. *TSO 4h.* Explain the characteristics of the given type of weft-knitted fabric.	**Unit-4.0 Weft Knitting** 4.1 Weft knit structures: Symbolic representation, features and properties of plain, rib, interlock and purl knit structure, ornamentation of plain-knit fabrics – using variation in yarn colour, count, twist and material, derivatives of plain knit (Single Jersey) – Knit and float, Knit and tuck, Knit, float and tuck 4.2 Needle Types: Latch needle, Bearded needle, Compound needle, advantages and limitations of each needle 4.3 Classification of Weft knitting machines: Flat knitting machine: Passage, knitting elements and knitting cycle Single jersey circular knitting machine: Passage, knitting elements- Needle, Sinker, Cams, Cylinder, Feed yarn carriers, Take-up mechanism, Operation Cycle – Clearing, Feeding, Knitting Position Double jersey (Rib, Interlock and Purl) circular knitting machine: Trick, cam, needle arrangement of cylinder and dial, operation cycle- Rest, Clearing, Feeding, Knitting Position 4.4 Characteristics of single jersey, rib, interlock and purl knit structure	**CO4**
TSO 5a. Describe the functions of elements of the given warp knitting machine. *TSO 5b.* Explain the passage, knitting elements and knitting cycle for the given type of warp knitting machine with sketches. *TSO 5c.* Describe with sketches the representations of the given warp-knit structures. *TSO 5d.* Determine the stitch length of the given fabric. *TSO 5e.* Calculate the production of the given knitting machine. *TSO 5f.* Determine the tightness factor of the given fabric. *TSO 5g.* Describe the given knitted fabric defect, its causes and remedies.	**Unit-5.0 Warp Knitting** 5.1 Basic warp knitting terms: overlap, underlap, open and closed lap 5.2 Classification of warp knitting machines- Tricot Machine, Raschel Machine: Knitting elements - needle bar, guide bar, sinker bar, pattern wheel, chain link and knitting cycle for latch and compound needle 5.3 Comparison of Tricot and Raschel Machines and Fabrics 5.4 Methods of representation – lapping movement and chain notation 5.5 Notations of warp knit structures: Pillar, Atlas, Tricot, Locknit, Sateen, reverse Locknut 5.6 Applications of warp-knitted Fabric 5.7 Important knitted fabric defects and their remedies 5.8 Calculations	**CO5**

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: S2428603D Some sample suggested assignments, micro-projects and other activities are mentioned here for reference.

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

1. Prepare a report on different fibres used in nonwoven.
2. Prepare a report on various types of nonwoven products, manufacturing processes, properties and applications in consumer products.
3. Prepare a report on various types of nonwoven products, manufacturing processes, properties and applications in industrial products.
4. Prepare a report on various types of nonwoven products, manufacturing processes, properties and applications in medical and healthcare products.
5. Prepare a comparative chart of different web bonding techniques.
6. Prepare a report on various types of needles used in knitting and write their specification.
7. Prepare a report on recent developments in knitting technology.
8. Prepare a report on weft-knitted structures for industrial applications.
9. List down common knitting faults.
10. Prepare a report on the application of knitted fabrics in technical and medical textiles.

b. Micro Projects:

1. Collect at least five samples of nonwoven products used as industrial products and prepare a booklet showing the special features for selecting the fabric for the relevant application.
2. Collect at least five samples of nonwoven products used as consumer products and prepare a booklet showing the special features for selecting the fabric for the relevant application.
3. Collect at least five samples of nonwoven products used as medical and healthcare products and prepare a booklet showing the special features for selecting the fabric for the relevant application.
4. Draw a detailed classification chart of fibre used in the nonwoven industry with examples of each variety.
5. Collect the information on different fibres used in nonwoven medical products by doing a local market survey and preparing a report.
6. Collect various samples of nonwoven filter fabrics study the Physical and chemical properties of filter fabrics and prepare a compile report.
7. Collect at least five knitted fabric samples according to end use and study their knit structure. Prepare a report on the knit structure used according to end-use.
8. Collect various types of needles and prepare a booklet by writing their specification.
9. Collect specifications of warp and weft knitting machines of different manufacturers and prepare a comparative chart.

c. Other Activities:

1. Seminar Topics:
    - Applications of nonwovens in technical textiles
    - Classification of nonwovens based on structure
    - Fibres used in the nonwoven industry
    - Types and suitability of yarns for knitting
    - Warp knitting technology and products
    - Advances in circular knitting
    - Faults their causes and remedies in knitted fabrics
    - Automation in weft knitting technology

2. Visits: Visit nearby nonwoven and knitting industry with modern types of machinery facilities and Prepare a report of the visit with special comments on modern machinery used, material used, single component/ batch production/ mass production and cost of production.

3. Self-Learning Topics:
   - Future trends of nonwovens
   - Nonwoven in medical textiles
   - Application of nonwoven in a car
   - Bi-component fibres
   - Recent developments in knitting technology
   - 3D Knitting Technology
   - Thermal comfort properties of knitted structures

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use the appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of 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%	20%	20%	-	-	-
CO-2	30%	30%	20%	20%	-	-	-
CO-3	10%	10%	20%	20%	33%	-	-
CO-4	20%	20%	20%	20%	33%	-	-
CO-5	20%	20%	20%	20%	34%	-	-
Total Marks	**30**	**70**	**20**	**20**	**10**	**-**	**-**
			50				

Legend:

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

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

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

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

Unit Title and Number	Total Classroom Instruction (Cl) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Introduction to Nonwoven	10	CO1	14	4	5	5
Unit-2.0 Web Bonding Methods and Finishing of Nonwovens	14	CO2	20	4	6	10
Unit-3.0 Introduction to Knitting	06	CO3	10	4	2	4
Unit-4.0 Weft Knitting	09	CO4	13	4	4	5
Unit-5.0 Warp Knitting	09	CO5	13	4	5	4
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): (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.	Handbook of Nonwovens	Russell S	Woodhead Publishing, India ISBN: 9781855736030
2.	Introduction to Nonwovens Technology	Batra, K.S. & Pourdeyhimi, B.	Destech Pubns Inc ISBN: 9781845696917
3.	Needle-punching	Purdy, A.T.	North Carolina State University ISBN: 9780900739323
4.	Nonwoven Fabrics: Raw Materials, Manufacture, Applications, Characteristics, Testing Processes	Albrecht, W., Fuchs, H. & Kittelmann.W	Wiley-VCH Verlag GmbH; 1st edition ISBN: 9783527304099
5.	Knitting Technology	Ajgaonkar, D.B.	Universal Publishing Corpn. ISBN:9788185027340
6.	Knitting Fundamentals, Machines, Structures and Developments	Anbumani, N.	New Age International Publishers ISBN: 9788122419542

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
7.	Knitting Technology	Spencer, J. David	Woodhead Publication Ltd. ISBN: 9781855733336
8.	Warp Knit Engineering	Reisfeld, A.	The Textile Institute, CRC Press, 1999 ISBN: 9781870372213
9.	Circular Knitting Technology	Iyer Chandrshekhar	Meisenbach, 1992 ISBN: 9783875250558

(b) Online Educational Resources:

1. https://archive.nptel.ac.in/courses/116/102/116102014/
2. https://archive.nptel.ac.in/courses/116/102/116102008/
3. https://archive.nptel.ac.in/courses/116/102/116102056/
4. https://www.textiletoday.com.bd/types-non-woven-fabrics-manufacturing-processes-applications
5. https://www.textileschool.com/352/non-woven-fabrics/
6. https://textilelearner.net/uses-of-non-woven-fabrics/
7. https://textiletutorials.com/knitting-technology-definition-and-types-of-knitting/
8. https://textilestudycenter.com/flat-knitting-technology/

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 Textile Institute Book Series
2. Autex Research Journal
3. Woodhead Publishing Series in Textiles

*****

A) Course Code : **2400604B (T2400604B/P2400604B/S2400604B)**

B) Course Title : Artificial Intelligence (Advance)

C) Pre- requisite Course(s) : Artificial Intelligence (Basic)

D) Rationale :

In Artificial Intelligence (Basic) course, students have learned the basics for Artificial Intelligence problem solving techniques, data analytics and articulates the different dimensions of these areas. This Artificial Intelligence (Advance) course offers the students the comprehension of Machine learning which is a subset of artificial intelligence in the field of computer. The course also exposes students to Tens or flow a Python-based open source library for numerical computation used in machine learning and developing neural networks. After completing the course students will be able to implement various techniques used in machine learning and neural networks using open source tools.

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

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

CO-1 Elaborate the use of Machine learning in Artificial Intelligence.

CO-2 Implement various supervised and unsupervised learning models and methods.

CO-3 Illustrate Artificial neural networks and its applications.

CO-4 Implement various Neural network models and Learning Methods.

CO-5 Solve machine learning and artificial neural network problems using Tens or flow.

F) Suggested Course Articulation Matrix (CAM):

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

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

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

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credit (C)
		L	T				
2400604B	Artificial intelligence (Advance)	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:

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)	
2400604B	Artificial Intelligence (Advance)	30	70	20	30	20	30	200

Legend:

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

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

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: T2400604B

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number (s)
TSO 1a. Describe the basic terminology of Machine learning TSO 1b. Explain the concept of dataset and ways to handle them TSO 1c. illustrate the process of dataset division TSO 1d. Explain process involved in machine learning	**Unit – 1: Introduction to machine learning** Concept of Machine Learning, Define Learning, Learn the Network, Evaluate the Network, datasets and ways to handle them, Feature sets, Dataset division: test, train and validation sets, cross validation. Applications of Machine Learning, processes involved in Machine Learning	**CO-1**
TSO 2a. Identify the category or class of a particular dataset using KNN algorithm TSO 2b. Use Linear regression for predictive analysis TSO 2c. Predict the categorical dependent variable using Logistic Regression TSO 2d. Use SVM for classification problems in Machine Learning TSO 2e. determine the performance of the classification models TSO 2f. evaluate the performance of the classification model using ROC-curve TSO 2g Explain characteristics of Unsupervised learning. TSO 2h. Explain different clustering methods TSO 2i. Implement K-means clustering algorithm to group the unlabeled dataset	**Unit 2: Supervised and unsupervised learning** **Supervised learning:** Introduction to Supervised Learning, K-Nearest Neighbor, Linear Regression, Logistic Regression, Support Vector Machine (SVM), Evaluation Measures: confusion matrix, precision, precision and recall, ROC-Curve (Receiver Operating Characteristic curve) **Unsupervised learning:** Introduction to Unsupervised Learning, Introduction to clustering, Types of Clustering: Hierarchical, Agglomerative Clustering and Divisive clustering; Partitional Clustering - K-means clustering. Expectation-Maximization (EM) Algorithm	**CO-2**
TSO 3a. Explain Structure and working of Biological Neural Network. TSO 3b. differentiate between Artificial Neural Network and Biological Neural Network TSO 3c. State key historical points in development of ANN TSO 3d. Explain the architecture of an artificial neural network	**Unit 3: Introduction to neural networks** Structure and working of Biological Neural Network, Fundamentals of Artificial Neural Networks & Applications, Characteristics of Artificial Neural Networks, History of neural network research, characteristics of neural networks terminology.	**CO-3**
TSO 4a. Use neuron McCulloch – Pitts model in designing logical operations TSO 4b. Apply Rosenblatt's Perceptron to solve linear classification problems TSO 4c. Implement Adaptive Linear Neuron (Adaline) training algorithm in neural network TSO 4d. Use Backpropagation neural training algorithm TSO 4e. Use ART (Adaptive Resonance Theory) learning model TSO 4f: Implement Bidirectional Associative Memory (BAM) model in Artificial Neural Network	**Unit 4: Neural networks models and Learning Methods** Models of neuron McCulloch – Pitts model, Rosenblatt's Perceptron, Adaline model, Basic learning laws, Topology of neural network architecture, Multilayer Neural Networks, Learning Methods, Backpropagation, Counter propagation, Adaptive Resonance Theory (ART), Associative memories, BAM.	**CO-4**
TSO 5a. Illustrate the features of Tens or flow TSO 5b. Manipulate tensors TSO 5c. Explain features of Tens or Board visualization TSO 5d Explain the concept and features of Tens or flow playground	**Unit-5 Tensor flow** features of TensorFlow, Tensor Data structure- Rank, shape, type, one dimension and two-dimension tensor, Tensor handling and manipulations, Tensor board	**CO-5**

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number (s)
	visualization- symbols Tensors, Variables, Automatic differentiation, Graphs and TF.function, modules layers and models, training loops, features of Tens or flow playground- data ,the ration of train and test data, features, hidden layers, Epoch, learning rate, activation function, regularization, problem type	

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400604B

Practical/Lab SessionOutcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Implement data classification algorithms	1	Write a program to implement k-Nearest Neighbour algorithm to classify the iris data set. Print both correct and wrong predictions. Python ML library classes can be used for this problem.	CO-2
LSO 2.1 Implement Machine learning algorithms LSO 2.2 Evaluate the performance of classification model	2	(a) Implement SVM for Iris Dataset- download the dataset from (https://gist.github.com/netj/8836201) (b) Find confusion matrix and evaluation matrix for SVM Hint: SVM model can be constructed using sklearn command, import pandas as pd from sklearn.svm import SVC from sklearn.model_selection import train_test_split from sklearn.metrics import confusion_matrix from sklearn.metrics import classification_report from sklearn.metrics import accuracy_score 1. Read the csv Iris dataset file 2. Condition the data 3. Condition the training and Testing data 4. Construct the Linear model 5. Test the model with Linear kernel 6. Prepare confusion matrix 7. prepare Classification Report	CO-2
LSO 3.1 Perform clustering operations using k-means algorithm	3	a) Explore k-means algorithm for the small sample dataset. b) Explore k-means algorithm for Iris Dataset	CO-2
LSO 4.1 Perform clustering operations using EM algorithm	4	Apply EM algorithm to cluster a set of data stored in a .CSV file. Use the same data set for clustering using k-Means algorithm. Compare the results of these two algorithms and comment on the quality of clustering. You can add Python ML library classes/API in the program.	CO-2
LSO 5.1 Build artificial neural network LSO 5.2 Test artificial neural network	5	Build an Artificial Neural Network by implementing the Backpropagation algorithm and test the same using appropriate data sets.	CO-4

Practical/Lab SessionOutcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 6.1 Detect features or business intelligence in the input data using perceptron	6	Implement the perceptron algorithm from scratch in python.	CO-4
LSO 7.1 Use Tensors for given problems	7	Write a programme to implement two dimension and three-dimension Tensor.	CO5
LSO 8.1 Use basic features for tensor handling and manipulations	8	Write a programme to add and multiply two 4x4 matrix, you can Import “tens or flow” and “numpy”.	CO5
LSO 9.1 Test artificial intelligence (AI) algorithms through the use of Google's TensorFlow machine learning libraries.	9	Solve a classification problem on the Tens or flow playground. Hint: refer https://www.educba.com/tensorflow-playground/	CO5
LSO 10.1 Implement artificial intelligence (AI) algorithms through the use of Google's TensorFlow machine learning libraries LSO 10.2 perform predictive analysis using linear regression	10	Implement algorithm for linear regression in tens or flow	CO5, CO2

L) Suggested Term Work and Self Learning: S2400604B Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

b. Micro Projects:
Use python programming for the solutions of Microproject problems

1. (a) Create a Bar plot to get the frequency of the three species of the Iris data.
   (b) Create a Pie plot to get the frequency of the three species of the Iris data.
   (c) Write a Python program to create a graph to find relationship between the sepal length and width.

2. (a) Write a Python program to split the iris dataset into its attributes (X) and labels (y). The X variable contains the first four columns (i.e. attributes) and y contains the labels of the dataset.
   (b) Write a Python program using Scikit-learn to split the iris dataset into 70% train data and 30% test data. Out of total 150 records, the training set will contain 120 records and the test set contains 30 of those records. Print both datasets.

3. Conduct performance analysis of Classification Algorithms (any 2) on a specific dataset.

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

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment(ETA)	Term Work & Self-Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	20%	15%	30%	20%	30%	--	--
CO-2	10%	25%	20%	20%	20%	30%	33%
CO-3	30%	25%	30%	20%	20%	--	--
CO-4	20%	20%	20%	20%	30%	30%	33%
CO-5	20%	15%	10%	20%	--	40%	34%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

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

** : Mentioned under point- (N)

\# : Mentioned under point- (O)

Note:

- The percentages 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. Introduction to machine learning	08	CO1	11	5	4	2
Unit-2.0. Supervised and unsupervised learning	10	CO2	18	5	6	7
Unit-3.0. Introduction to neural networks	10	CO3	17	5	7	5
Unit-4.0 Neural networks models and Learning Methods	10	CO4	14	3	3	8
Unit-5.0. Tensor flow	10	CO5	10	2	6	2
Total Marks	**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.	Write a program to implement k-Nearest Neighbor algorithm to classify the iris data set. Print both correct and wrong predictions. Python ML library classes can be used for this problem.	CO-2	-	90	10
2.	(a) Implement SVM for Iris Dataset- download the dataset from (https://gist.github.com/netj/8836201) (b) Find confusion matrix and evaluation matrix for SVM	CO-2	-	90	10
3.	a) Explore k-means algorithm for the small sample dataset. b) Explore k-means algorithm for Iris Dataset	CO-2	20	70	10
4.	Apply EM algorithm to cluster a set of data stored in a .CSV file. Use the same data set for clustering using k-Means algorithm. Compare the results of these two algorithms and comment on the quality of clustering. You can add Python ML library classes/API in the program.	CO-2	-	90	10
5.	Build an Artificial Neural Network by implementing the Backpropagation algorithm and test the same using appropriate data sets.	CO-4	10	80	10
6.	Implement the perceptron algorithm from scratch in python.	CO-4	10	80	10
7.	Write a programme to implement two dimension and three-dimension Tensor.	CO-5	-	90	10
8.	Write a programme to add and multiply two 4x4 matrix, you can Import “tens or flow” and “numpy”.	CO-5	-	90	10
9.	Solve a classification problem on the Tens or flow playground.	CO-5	20	70	10
10.	Implement algorithm for linear regression in tens or flow	CO-2, CO-5	10	80	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 beprepared by the course teacher for each experiment/practical to assess the student performance.

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	Computer Systems	Desktop Computers with i3 processor, 16 GB RAM, 512 GBHDD	S. No. 1 to 10
2.	Online Python IDE	https://www.online-python.com/	S. No. 1 to 10

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
3.	Jupyter Notebook	Download from https://jupyter.org/	S. No. 1 to 10
4.	Pip Python package manager	Download Pip 22.3 From https://pypi.org/project/pip/	S. No. 1 to 10
5.	Google colab	https://colab.research.google.com/github/tensorflow/docs/blob/master/site/en/tutorials/quickstart/beginner.ipynb#scrollTo=DUNzJc4jTj6G	S. No. 1 to 10
6.	Various modules, Libraries and Packages	Tens or flow, NumPy, Pandas, package	S. No. 1 to 10

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Machine Learning using Python	Manaranjan Pradhan, U Dinesh Kumar	Wiley, ISBN-10: 8126579900 ISBN-13: 978-8126579907
2.	Introduction to Machine Learning	Jeeva Jose	Khanna Book Publishing Co. (P) ltd, 2020. ISBN-10: 9389139066 ISBN-13: 978-9389139068
3.	Machine Learning for Dummies	John Paul Mueller and Luca Massaron, For Dummies,	For Dummies; 2nd edition, ISBN-10: 1119724015 ISBN-13: 978-1119724018
4.	Machine Learning	Rajeev Chopra	Khanna Book Publishing Co., 2021 ISBN-10: 9789386173423 ISBN-13: 978-9386173423
6.	Learn TensorFlow 2.0: Implement Machine Learning and Deep Learning Models with Python	Pramod Singh, Avinash manure	Apress, 978-1484255605 ISBN-10: 1484255607 ISBN-13: 978-1484255605

(b) Online Educational Resources:

1. NPTEL Course: Introduction to Machine Learning, Prof. Balaraman Ravindran, IIT Madras
2. https://www.tensorflow.org/resources/learn-ml
3. https://www.tutorialspoint.com/tensorflow/index.htm
4. https://www.javatpoint.com/tensorflow
5. https://developers.google.com/machine-learning/crash-course/exercises

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

(c) Others:

Data Source:

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

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A) Course Code : **2400604C (T2400604C/P2400604C/S2400604C)**

B) Course Title : Internet of Things (Advance)

C) Pre- requisite Course(s) : IoT (Basics), Computer Networks

D) Rationale :

The rise and rise of IoT technologies ae redefining business opportunities and process. This has led to a growing need to learn advance skills to remain competitive in the market. Put together, these are a potent combination of technologies that will dictate how our future is written, which is a strong indicator of rewarding job opportunities in those domains. Introduction of the Advanced IoT follows a rigorous curriculum which blends the academic excellence and industry-relevant applications.

This course will be exposed to a breadth of skills which will help students to become multi-faceted software engineers with a deeper understanding of these modern technologies, their applications, and interdependence.

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

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

CO-1 Use basic Python features in Programming.

CO-2 Use advance Python features in Programming.

CO-3 Explain features of Cloud and IoT data storage on it.

CO-4 Explain IoT Networking and its application.

CO-5 Develop IoT App for the given problem

F) Suggested Course Articulation Matrix (CAM):

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

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

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

G) Teaching & Learning Scheme:

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				
2400604C	IoT (Advance)	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:

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)	
2400604C	IoT (Advance)	30	70	20	30	20	30	200

Legend:

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

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

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: T2400604C

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.1. a. Write the steps to install Python. TSO.1. b. Explain given types of variables in python. TSO.1. c. Explain use and importance of Tuple, Dictionary, operators in python TSO.1. d. Explain use of array in python. TSO.1. e. Explain use of 2-Dimensional Array in python TSO.1. f Explain uses of given type of Conditional statement in python.	**Unit-1.0 Python Basics: -** 1.1 Installation of Python 1.2 Variables, Print () function, Escape character sequence and run python Program 1.3 Python Tuple, Dictionary, operators 1.4 Python arrays, create, reverse and append data into it. 1.5 Python 2 Dimensional arrays. 1.6 Python Conditional statement.	**CO-1 and CO-5**
TSO.2. a. Explain uses of given type of do & while loops in python TSO.2. b. Explain working of break, continue and pass statement in python TSO.2. c. Write the benefits of using OOP methodology in python. TSO.2. d. Explain given type of string operation related to python. TSO.2. e. Explain given function in python TSO.2. f Explain use of Lambda function in python.	**Unit 2.0 Python Advance: -** 2.1 Python Do & while loops 2.2 Python break, continue, pass statements 2.3 Python OOPs Class, Object, Inheritance and Constructor 2.4 Python Strings Replace, Join, Split, Reverse, Uppercase, Lowercase, count, find, split and length 2.5 Python Functions, Built-in functions and user defined functions 2.6 Lambda function and uses	**CO-1 and C05**
TSO.3. a. Differentiate between Cloud and IoT cloud. TSO.3. b. Explain features of Cloud in IoT environment TSO.3. c. List features of various types of Cloud TSO.3. d. List features of cloud services like SaaS, PaaS and IaaS TSO.3. f List advantages of cloud data storage. TSO.3. g Explain Arduino architecture and its applications. TSO.3.h Explain Raspberry pi architecture and its applications.	**Unit-3.0 Cloud Features: -** 3.1 Cloud computing and IoT cloud 3.2 Benefits of cloud in IoT 3.3 Types of Cloud public, private and hybrid 3.4 Cloud services like SaaS, PaaS and IaaS 3.5 Cloud connectivity and Data storage on Cloud. 3.6 Arduino: Architecture, Programming, and Applications 3.7 Raspberry Pi Architecture, Programming, and Application basic level for IoT applications	**CO-1, CO-2 and CO-5**
TSO.4. a. Explain wired network TSO.4. b. Explain short range wireless network TSO.4. c. Explain M2M communication TSO.4. d. Explain various generation of wireless network TSO.4. e. Explain the importance of LWPAN in IoT TSO.4. f Differentiate between SigFox & LoRaWAN TSO.4. g Explain use of NB-IOT (Narrow Band IOT) TSO.4.h Create heterogenous network using RFID.	**Unit.4.0 IoT Networking and Application: -** 4.1 Wired and short-range wireless network 4.2 M2M – 2G, 3G, 4G & 5G networks 4.3 LPWAN – Low Power Wide Area Networks 4.4 SigFox & LoRaWAN. 4.5 NB-IOT (Narrow Band IOT) 4.6 RFID and Bar code basics- Components of an RFID system-Data -Tags-Antennas- Connectors-Cables- Readers- encoder/ printers for smart labels- Controllers software 4.7 RFID advantages over Bar codes.	**CO-1 and CO-4**
TSO.5. a. Identify suitable framework for IoT app development TSO.5. b. Identify various stages of selected app TSO.5. c. Develop the app.	**Unit. 5.0 IoT App Development**: - 5.1 Framework selection for IoT app development 5.2 Identify stages of app to be developed. 5.3 Develop, Implement, and Deploy the App	**CO-4 and CO-5**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.5. d. Implement and deploy the app TSO.5. e Maintain and improve the app based on the feedback	5.4 Testing and Integration 5.5 Maintain and improve	

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400604C

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Python installation LSO 1.2 Prepare and run python program on given problem LSO 1.3 Prepare python program on Dictionary, Tuple and operators. LSO 1.4 Prepare program on arrays LSO 1.5 Prepare a program on 2-dimensional array LSO 1.6 Create program on conditional statement	1.	1.1 Install given version of Python on the computer system. 1.2 Prepare a python program using print() function and run it. 1.3 Access given value from the tuple 1.4 Print the given value of key from the dict. 1.5 Write a Python program to create an array of 5 integers and display the array items. Access individual element through indexes 1.6 Write a Python program which takes two digits m (row) and n (column) as input and generates a two-dimensional array. 1.7 Write a python program to check whether person is eligible for voting or not. (accept age from the user) 1.8 Write a python program to check whether the entered number is even or odd. 1.9 Write a python program to check whether entered number is divisible by another entered number. 1.10 Write a python program to display “Yes” is entered number is divisible by 5 otherwise display “No”	CO-1
LSO 2.1 Prepare python program on Do & while loops LSO 2.2 Prepare python program on break and continue statement. LSO 2.3 Prepare Python program using break and continue statements LSO 2.4 prepare python program using OOP LSO 2.5 Prepare Python program using functions	2.	2.1 Prepare a python program which can print first 10 even and odd numbers using while statement 2.2 Write a python program which can print first 10 integers and its square using while/for loop. 2.3 Write a python program which can print sum of first 10 natural numbers using while/for loop. 2.4 Write a python program which can identify the prime number between the range given using while/for loop. 2.5 Consider a situation where you want to iterate over a string and want to print all the characters until a letter ‘e’ or ‘s’ is encountered. It is specified that you have to do this using loop and only one loop is allowed to use.	CO-2

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
		2.6 Consider the situation when you need to write a program which prints the number from 1 to 10 and but not 6. It is specified that you have to do this using loop and only one loop is allowed to use. 2.7 Create a Class with instance attributes 2.8 Create a Vehicle class without any variables and methods 2.9 Write a Python function to find the Max of three numbers. 2.10 Write a Python program to reverse a string.	
LSO 3.1 Signup for free cloud storage LSO 3.2 Store data into cloud and retrieve it.	3.	3.1 Create a free cloud account 3.2 Store data on cloud and retrieve it	CO-3
LSO 4.1 Design various types of network cables LSO 4.2 Connect computer in LAN. LSO 4.3 Connect devices using wireless network LSO 4.4 Connect machine with machine LSO 4.5 Connect devices using IEEE 802 LSO 4.6 Connect devices using LPWAN LSO 4.7 Connect devices using RFID	4	4.1 Study of different types of Network cables and Practically implement the cross-wired cable and straight through cable using clamping tool. 4.2 Connect the computers in Local Area Network 4.3 Connect 2 or more devices using Bluetooth 4.4 Connect 2 or more devices using infrared 4.5 Connect 2 more machine using m2m 4.6 Connect 2 or more different devices using access point 4.7 Connect 2 devices using LPWAN (Smart Meter) 4.8 Connect 2 or more devices using RFID	CO-4
LSO 5.1 Develop a IoT app LSO 5.2 Develop IoT applications using smartphones.	5.	5.1 Identify a problem and develop an app 5.2 Building a temperature monitoring system using sensors and Smartphone	CO-5

L) Suggested Term Work and Self Learning: S2400604C Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

b. Micro Projects:

1. Prepare a report on Python programming language.
2. Develop a small software in python to solve a IoT data analysis.
3. Create an id on free cloud storage and share data on it for others.
4. Create a heterogenous network and connect different dives.
5. Create a an IoT app for the identified problem

c. Other Activities:

1. Seminar Topics: - “Future of wireless network.”
2. “Smart electricity billing “, “Cloud computing and IoT”
3. Visit to industry for IoT implementation in industrial process.

4. Reading RFID cards using 8051- RFID in the supply chain- Vehicles parking using RFID- library management system- electronic toll payment- smart shipping containers fleet monitoring and management.
5. Building IoT Applications like pressure, air quality, temperature and motion detector using Arduino and raspberry-pi Universal boards.
6. Surveys of market for availability of various types of network devices and its pricing.
7. Product Development: Development of projects for real life problem solution app.
8. Software Development: Using Python

d. Self-Learning Topics:

1. Deeper knowledge in Python features
2. Network devices and its capabilities
3. Advantages of IoT implementations

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

Cos	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self-Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	10%	10%	20%	--	33%	10%	20%
CO-2	15%	10%	20%	--	33%	15%	20%
CO-3	30%	30%	20%	--	34%	15%	20%
CO-4	20%	30%	20%	50%	--	30%	20%
CO-5	25%	20%	20%	50%	--	30%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

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

******: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentages 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 Python basics	5	CO1	7	2	2	3
Unit-2.0 Python Advance	5	CO1, CO2	7	2	2	3
Unit-3.0 Cloud features	14	CO3	21	8	8	5
Unit-4.0 Networking and Application	14	CO4, CO3	21	5	7	9
Unit-5.0 IoT Applications	10	CO5, CO3 and CO4	14	3	6	5
Total Marks	**48**		**70**	**20**	**25**	**25**

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA /ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Install given version of Python the computer system.	CO-1	70	20	10
2.	Prepare a python program using print() function and run it.	CO-1	60	30	10
3.	Access given value from the tuple	CO-1	60	30	10
4.	Print the given value of key from the dict.	CO-1	60	30	10
5.	Write a Python program to create an array of 5 integers and display the array items. Access individual element through indexes	CO-1	60	30	10
6.	Write a Python program which takes two digits m (row) and n (column) as input and generates a two-dimensional array.	CO-1	60	30	10
7.	Write a python program to check whether person is eligible for voting or not. (accept age from the user)	CO-1	60	30	10
8.	Write a python program to check whether the entered number is even or odd.	CO-1	60	30	10
9.	Write a python program to check whether entered number is divisible by another entered number.	CO-1	60	30	10
10.	Write a python program to display “Yes” is entered number is divisible by 5 otherwise display “No”	CO-1	60	30	10
11.	Prepare a python program which can print first 10 even and odd numbers using while statement	CO-2	60	30	10
12.	Write a python program which can print first 10 integers and its square using while/for loop.	CO-2	60	30	10

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA /ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
13.	Write a python program which can print sum of first 10 natural numbers using while/for loop.	CO-2	60	30	10
14.	Write a python program which can identify the prime number between the range given using while/for loop.	CO-2	60	30	10
15.	Consider a situation where you want to iterate over a string and want to print all the characters until a letter 'e' or 's' is encountered. It is specified that you have to do this using loop and only one loop is allowed to use.	CO-2	60	30	10
16.	Consider the situation when you need to write a program which prints the number from 1 to 10 and but not 6. It is specified that you have to do this using loop and only one loop is allowed to use.	CO-2	60	30	10
17.	Create a Class with instance attributes	CO-2	60	30	10
18.	Create a Vehicle class without any variables and methods	CO-2	60	30	10
19.	Write a Python function to find the Max of three numbers.	CO-2	60	30	10
20.	Write a Python program to reverse a string.	CO-2	60	30	10
21.	Create a free cloud account	CO-3	70	20	10
22.	Store data on cloud and retrieve it.	CO-3	60	30	10
23.	Study of different types of Network cables and Practically implement the cross-wired cable and straight through cable using clamping tool.	CO-4	70	20	10
24.	Connect the computers in Local Area Network	CO-4	70	20	10
25.	Connect 2 or more devices using Bluetooth	CO-4	70	20	10
26.	Connect 2 or more devices using infrared	CO-4	70	20	10
27.	Connect 2 more machine using m2m	CO-4	70	20	10
28.	Connect 2 or more different devices using access point	CO-4	70	20	10
29.	Connect 2 devices suing LPWAN (Smart Meter)	CO-4	70	20	10
30.	Connect 2 or more devices using RFID	CO-4	70	20	10
31.	Identify a problem and develop an app	CO-5	70	20	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1	Python software	Openly available as per instruction	As mentioned above list
2	Cables connecters and crimping tools	Cat 6e cable, RJ-45 connectors and Crimping Tool	
3	Bluetooth and infrared devices	Any mobile and wireless keyboard and mouse	
4	IoT free cloud	Free available	
5	Smart devices	Like meters, bulbs etc.	
6	Wireless access point	Wireless router or access point	-
8	Arduino development board	Arduino Uno and Arduino Nano.	-
6	Raspberry Pi	Raspberry Pi 4/ Raspberry Pi 3/ Raspberry Pi 2	-

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1	Let Us Python	Kanetkar Yashavant	BPB Publications ISBN: 9789388511568, 9789388511568
2	IOT (Internet of things) and Its Application	P K Pandey	T Balaji Publication (1 January 2020) ISBN-10: 8194136385 ISBN-13: 978-8194136385
3	Raspberry Pi Cookbook: Software and Hardware Problems and Solutions	Simon Monk	Shroff/O'Reilly; Third edition (4 October 2019) ISBN-10: 9352139267 ISBN-13: 978-9352139262
4	Raspberry Pi Cookbook: Software and Hardware Problems and Solutions,	Simon Monk	Shroff/O'Reilly; Third edition (4 October 2019) ISBN-10: 9352139267 ISBN-13: 978-9352139262
5	Cloud Computing: Concepts, Technology & Architecture	Erl	Pearson Education India; 1st edition (1 January 2014), ISBN-10: 9332535922 ISBN-13: 978-9332535923

(b) Online Educational Resources:

1. nptel.iitm.ac.in/courses/.../IIT.../lecture%2023%20and%2024.htm
2. en.wikipedia.org/wiki/Shear_and_moment_diagram
3. www.freestudy.co.uk/mech%20prin%20h2/stress.pdf
4. www.engineerstudent.co.uk/stress_and_strain.html
5. https://www.iit.edu/arc/workshops/pdfs/Moment_Inertia.pdf
6. https://www.veritis.com/blog/aws-vs-azure-vs-gcp-the-cloud-platform-of-your-choice/
7. https://wiki.python.org/moin/TimeComplexity
8. www.engineerstudent.co.uk/stress_and_strain.html
9. https://www.iit.edu/arc/workshops/pdfs/Moment_Inertia.pdf

Amini, P. (2014). Sulley: Pure Python fully automated and unattended fuzzing frame- work. https://github.com/OpenRCE/sulley

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

(c) Others:

1. Learning Packages
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

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A) Course Code : **2400604D (T2400604D/P2400604D/S2400604D)**

B) Course Title : Drone Technology (Advance)

C) Pre- requisite Course(s) : Drone Technology (Basics)

D) Rationale :

In previous semester, a course in drone technology broadly discussed about basic principles, functions and interface of different components and design simple drone structure. In order to understand the successive development of drones / UAVs in terms of their geometric structure, working methodology and navigation control etc., so it is important to study the advanced course on Drone Technology. This course includes the study of Static and dynamic force analysis on drone, advance flying features, navigation control, maintenance and advance applications of different types of drone.

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

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

CO-1 Apply the concept of engineering mechanics for stability of drone.

CO-2 Design the structure of drone using GPS module and thermal Image camera.

CO-3 Operate drone using advance flight controller board.

CO-4 Perform drone maintenance and assembly.

CO-5 Use drone in advance applications like precision agriculture, security, IoT, etc.

F) Suggested Course Articulation Matrix (CAM):

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

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

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

G) Teaching & Learning Scheme:

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				
2400604D	Drone Technology (Advance)	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:

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)	
2400604D	Drone Technology (Advance)	30	70	20	30	20	30	200

Legend:

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

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

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

J) Theory Session Outcomes (TSOs) and Units: T2400604D

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 1a. Draw free body diagram of quadcopter drone. TSO 1b. Determine centroid of given drone structure. TSO 1c. Determine center of gravity of different drone structure. TSO 1d. Analyze different types of force acting drone system. TSO 1e. Differentiate between static and dynamic force analysis. TSO 1f. Explain how gyroscopic motion keeps drone balanced and hovering.	**Unit-1.0 Engineering mechanics for Drone Technology** 1.1 Drone Mechanics • Free body diagram of drone • Method of finding resultant of force system • Equilibrium of coplanar force system 1.2 Center of Gravity • Centroid of plane figure • Center of gravity of solid bodies 1.3 Force analysis in drone • Force analysis in drone • Forces of flight • Principle axes and rotation of aerial systems 1.4 Dynamics of machine • Static and dynamic force analysis • Gyroscopic motions	**CO-1**
TSO 2a. Describe properties and application of smart materials use in UAV frame. TSO 2b. Calculate the diameter of the propeller for given drone frame size. TSO 2c. Determine size of quadcopter frame and diameter of propeller of drone TSO 2d. Describe working of GPS and its hardware interfacing. TSO 2e. Write steps to interface GPS module for drone navigation. TSO 2f. Describe different RF blocks and antennas used in RF transmitter and receiver.	**Unit-2.0 Drone Frame and Components** 2.1 Drone frame design • Calculation principle for drome frame sizes • Quadcopter frame design • Smart materials for UAV frame • Green material uses in drone 2.2 Advance Drones component • GPS, Interfacing of GPS hardware • Thermal and chemical sensor • Tilt and LiDAR sensor 2.3 RF transmitter and receiver • RF blocks • RF antennas 2.4 Micro-electromechanical systems (MEMS) based sensor 2.5 HD and thermal Image camera	**CO-2**
TSO 3a. Identify features and specifications of FCB use in different application TSO 3b. Explain ports of any given advance flight controller board. TSO 3c. Write steps of software installation of flight controller board. TSO 3d. Describe installation and calibration steps of radio telemetry with FCB. TSO 3e. Write steps of calibration of accelerometer and ESC with FCB.	**Unit-3.0 Advance flight controller Board (FCB)** 3.1 Specification and ports of FCB 3.2 Software for FCB • Software installation 3.3 Radio Communication with FCB • Installation of Radio Telemetry • Radio Calibration with FCB 3.4 Calibration of accelerometer 3.5 Calibration of ESC 3.6 Interface of motor with FCB using ESC	**CO-3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number (s)
TSO 3f. Describe interfacing of GPS with FCB.	3.7 GPS interface with FCB 3.8 Safety features of advance FCB	
TSO 4a. Describe challenges comes in drone maintenance. TSO 4b. Describe measuring devices and instrument use in drone maintenance. TSO 4c. Describe measuring instrument used to measure electrical parameters in drone. TSO 4d. Write sequence of steps use in assembling of drone.	**Unit-4.0 Maintenance and assembling of Drone** 4.1 Need and scope of drone maintenance 4.2 Types of maintenance 4.3 Routine drone maintenance and its checklist • Recording basic details • Structural inspection • Battery check • Software/firmware 4.4 Types of measuring instrument use in drone maintenance 4.5 Measurement of different electrical parameters related with drone hardware 4.6 Assembly of drones • Concept of interchangeability • Principle of gauging and their applicability in drone assembly • Parameters and profile measurements of standard propellers • Concepts of drone assembly using 3D modeling	**CO-4**
TSO 5a. Describe function of autonomous drone using AI. TSO 5b. Describe IoT enable UAV for surveillance and data gathering. TSO 5c. Explain drone applications based on cost saving, enhanced efficiency and profitability aspects.	**Unit-5.0 Advance Drone Application** 5.1 Application of AI in Drone Technology 5.2 IoT and Computer vision integrated Drone 5.3 Drone interface with smart-phone 5.4 Drone Applications in • Military • Precision Agriculture	**CO-5**

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400604D

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Use the force of gravity to compute the centre of gravity for a given drone structure.	1.	Determine Centre of gravity of different done structure.	CO-1
LSO 2.1 Develop skills of observation and interpreting phenomenal changes on Drone model for stability and hovering.	2.	Demonstrate gyroscopic effect on a drone model	CO-1
LSO 3.1 Draw various frame to be required in designing drone structure. LSO 3.2 Use Measuring instrument in designing drone frame. LSO 3.3 Choose suitable materials for making drone frame	3.	Compare different types of airframe structure like quadcopter frame (plus shape, cross shape and H-shape), hexacopter frame (hexa + and hexa S).	CO-2, CO-4

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 4.1 Identify and measure the condition of sensors. LSO 4.2 Interface Tilt and LiDAR sensors in drone.	4.	Test Tilt and LiDAR sensors and their characteristics with Microcontroller based Flight controller board.	CO-2
LSO 5.1 Identify different component of GPS module LSO 5.2 Measure and use signals from GPS module to determine latitude & longitude. LSO 5.3 Diagnose problems using appropriate instruments/tools related to GPS navigation.	5.	Demonstrate the interfacing of GPS module to drone navigation.	CO-2, CO-3
LSO 6.1 Measure characteristics of HD and thermal Image camera. LSO 6.2 Diagnose common problems related to HD and thermal Image camera.	6.	Test HD and thermal Image camera and their characteristics.	CO-2
LSO 7.1 Identify the characteristics of RF circuit blocks like amplifier, and filters. LSO 7.2 Identity different antennas used. LSO 7.3 Operate drone using RC transmitter and receiver.	7.	Identify, configure and operate 433MHz and 2.4 GHz RC transmitter and receiver.	CO-2
LSO 8.1 Test the different peripheral interconnections with FCB LSO 8.2 Troubleshoot advance Flight control board (FCB)	8.	Programming and configure of parameters in flight control board (FCB).	CO-3
LSO 9.1 Configure radio communication device to control drones. LSO 9.2 Operate drone using RC transmitter and receiver.	9.	Test and perform communication of advance Flight control board with RF transceiver.	CO-3, CO-2
LSO 10.1 Measure various parameters of GPS system LSO 10.2 Interface GPS system with flight controller board.	10.	Test and perform communication of Flight control board (FCB) with GPS	CO-3, CO-2
LSO 11.1 Configure HD and thermal image camera with drone. LSO 11.2 Demonstrate use of HD and thermal image camera with FCB	11.	Test and troubleshoot HD and thermal image camera with advance FCB in drone.	CO-3, CO-2
LSO 12.1 Measure voltage, current frequency using Digital Multimeter LSO 12.2 Measure peak to peak voltage, time period, and duty cycle using DSO and waveform generator. LSO 12.3 Measure unknown frequency and its level using spectrum analyzer.	12.	Measure various electric parameters in drone hardware	CO-4
LSO 13.1 Inspect drone as per the given checklist LSO 13.2 Diagnose drone problems after flying of 50 and 100hrs	13.	Perform preventive maintenance of drone components	CO-4
LSO 14.1 Perform dismantle process of drone. LSO 14.2 perform services need for operation LSO 14.3 Check and Install different parts of the drone system. LSO 14.4 Assemble drone component.	14.	Dismantle and service of different parts of drone system	CO-4

L) Suggested Term Work and Self Learning: S2400604D Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

b. Micro Projects:

1. Prepare maintenance report for small UAV.
2. Survey nearby electronics shop and Prepare report on types of drone frames and drone sensors available and its specification.
3. Prepare report of surveying & mapping of our institute using drone with HD and thermal image camera.
4. Prepare report on land and crops quality of nearby agriculture field using drone.
5. Prepare report on Identify and select different application drones like agriculture, Surveillance, Inspections and gathering Information for disaster management.
6. Download 5 videos on advance FCB of drone design. Watch them and write report on it.
7. Market survey on different types of FCB, its specification and specific application and prepare report.
8. Develop mission completion drone with the help of GPS based Advance FCB.

c. Other Activities:

1. Seminar Topics-Drone stability using gyroscopic motion, Quadcopter frame, Green material use in drone design, GPS based drones, types of HD and thermal Image camera, Safety features in advance drone, Drone Assembling, Military drone.
2. Visits: Visit nearby small industry, Drone institute facilities. Prepare report of visit with special comments of advance drone technology used, material used, cost of printed component.
3. Surveys: Survey nearby electronics shop and Prepare report of list of advance drone components and its specification.
4. Product Development
5. Software Development

d. Self-Learning Topics:

1. Different types Drones frame
2. Overview of GPS technology
3. Different types of HD and thermal Image camera
4. Safety features in Drone
5. Advance drone application

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

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

Legend:

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

******: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

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

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

Unit Title and Number	Total Classroom Instruction (Cl) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit 1.0 Engineering mechanics for Drone Technology	8	CO-1	12	04	04	04
Unit 2.0 Drone frame and components	10	CO-2	14	04	04	06
Unit 3.0 Advance Flight Controller Board	12	CO-3	16	04	06	06
Unit 4.0 Maintenance and assembling of drone	10	CO-4	16	04	06	06
Unit 5.0 Advance Drone Application	8	CO-5	12	04	04	04
Total Marks	**48**		**70**	**20**	**24**	**26**

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA /ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Determine Centre of gravity of different done structure.	CO-1	50	40	10
2.	Demonstrate gyroscopic effect on a drone model	CO-1	40	50	10
3.	Compare different types of airframe structure like quadcopter frame (plus shape, cross shape and H-shape), hexacopter frame (hexa + and hexa S).	CO-2	50	40	10
4.	Test Tilt and LiDAR sensors and their characteristics with Microcontroller based Flight controller board.	CO-2	50	40	10
5.	Demonstrate the interfacing of GPS module to drone navigation.	CO-2, CO-3	50	40	10
6.	Test HD and thermal Image camera and their characteristics.	CO-2	50	40	10
7.	Identify, configure and operate 433MHz and 2.4 GHz RC transmitter and receiver.	CO-2	60	30	10
8.	Programming and configuration of parameters in flight control board (FCB).	CO-3	60	30	10
9.	Test and perform communication of advance Flight control board with RF transceiver.	CO-3, CO-2	60	30	10
10.	Test and perform communication of Flight control board (FCB) with GPS	CO-3, CO-2	60	30	10
11.	Test and troubleshoot HD and thermal image camera with advance FCB in drone.	CO-3, CO-2	60	30	10
12.	Measure various electric parameters in drone hardware	CO-4	40	50	10
13.	Perform preventive maintenance of drone components	CO-4	60	30	10
14.	Dismantle and service of different parts of drone system	CO-4	60	30	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	Drone Frame	Tricopter/Quadcopter/Hexacopter	1-15
2.	Propellers	15 X 5.5 CW/Others	1-15
3.	GPS module	M8N Series	1-15
4.	Drone Camera	15-20 Megapixel	1-15
5.	Camera Gimble	3 Axis feature, 360 Degree movement	1-15
6.	Tilt Sensor	8-30 volt	1-15
7.	LiDER sensor	Range 75m to 200m	1-15
8.	Battery	Lithium Polymer Battery,8000 to 10000 mAh	1-15
9.	Motor	BLDC, 370kv	1-15
10.	Electronic speed Controller (ESC)	40 Amp	1-15
11.	Flight Controller Board	CC3D/Pixhawk/Others	1-15
12.	Transmitter and Receiver for radio signal	10 Channels and more, 2.4 GHz & 5.8 GHz	1-15
13.	Embedded system for AI application on UAV	Open Source Jetson Baseboard /Others	1-15

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author (s)	Publisher and Edition with ISBN
1.	Make: DIY Drone and Quadcopter Projects: A Collection of Drone-Based Essays, Tutorials, and Projects	Editors of Make	Shroff/Maker Media, First edition 2016, ISBN-978-9352133994
2.	Make: Getting Started with Drones: Build and Customize Your Own Quadcopter	Terry Kilby & Belinda Kilby	Shroff/Maker Media, First edition 2016, ISBN-978-9352133147
3.	Agricultural Drones: A Peaceful Pursuit	K R Krishna	Apple Academic Press,1st edition 2018, ISBN-978-1771885959
4.	Building Multicopter Video Drones: Build and fly multicopter drones to gather breathtaking video footage	Ty Audronis	Packt Publishing Limited; Illustrated edition,2014, ISBN-978-1782175438
5.	The Complete Guide to Drones	Adam Juniper	Ilex Press, Extended 2nd Edition,2018 ISBN-9781781575383
6.	Unmanned Aircraft Systems - UAVS Design, Development and Deployment (Aerospace Series)	R Austin	John Wiley & Sons Inc, 1st edition, 2010, ISBN-978-0470058190

(b) Online Educational Resources:

1. https://archive.nptel.ac.in/courses/101/104/101104083/
2. https://onlinecourses.nptel.ac.in/noc21_ae14/preview
3. https://en.wikipedia.org/wiki/Unmanned_aerial_vehicle
4. https://fusion.engineering/
5. https://robocraze.com/blogs/post/best-flight-controller-for-drone
6. https://www.youtube.com/watch?v=lrkFG7GilPQ
7. https://www.youtube.com/watch?v=KjG6FKCNCbM
8. https://ardupilot.org/
9. https://px4.io/

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

(c) Others:

1. Development of an Autonomous IoT-Based Drone for Campus Security, Abdelrahman Mahmoud Gaber, Rozeha A. Rashid, Nazri Nasir, Ruzairi Abdul Rahim, M. Adib Sarijari, A. Shahidan Abdullah, Omar A. Aziz, Siti Zaleha A. Hamid, Samura Ali,2021
2. IoT based UAV platform for emergency services; S. K. Datta, J. L. Dugelay, & C. Bonnet, 2018
3. Development of an Autonomous Drone for Surveillance Application; M. A. Dinesh, S. Santhosh Kumar, J. Sanath, K. N. Akarsh & K. M. Manoj Gowda,2018
4. Autonomous cloud-based drone system for disaster response and mitigation; C. Alex & A. Vijaychandra,2016
5. https://www.geeetech.com/Documents/CC3D%20flight%20control%20board.pdf
6. https://www.bhphotovideo.com/lit_files/201146.pdf
7. http://tricopter.hu/docs/cc3d_manual.pdf

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A) Course Code : **2400604E (T2400604E/P2400604E/S2400604E)**

B) Course Title : 3D Printing and Design (Advance)

C) Pre- requisite Course(s) : 3D Printing and Design (Basic)

D) Rationale :

This advanced course on 3D Printing tries to develop understanding of the process of making real complex objects from digital models in the students using various 3D printing processes and materials (Plastics, Ceramics and Metals). It also covers the post processing required and details about various printing process and parameters to make a quality 3D printed component. This course can only be taken up after completing 3D Printing and Design (Basic) course offered in previous semester.

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

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

CO-1 Select newer 3D Printing material for various applications.
CO -2 Use solid based 3D Printing processes to develop products.
CO-3 Use liquid-based 3D Printing processes to develop products.
CO-4 Use powder-based 3D Printing processes to develop products.
CO-5 Apply post processing techniques and quality checks on 3D printed components.

F) Suggested Course Articulation Matrix (CAM):

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

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

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

G) Teaching & Learning Scheme:

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				
2400604E	3D Printing and Design (Advance)	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:

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)	
2400604E	3D Printing and Design (Advance)	30	70	20	30	20	30	200

Legend:

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

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

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: T2400604E

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain various forms of 3D printing raw material. *TSO 1b.* Select material for the given popular 3D printing processes with justification.	**Unit-1.0 3D Printing Materials** 1.1 Various forms of 3D printing raw material- Liquid, Solid, Wire, Powder.	**CO1**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1c. Select various Polymer based 3D printing raw materials with justification. *TSO 1d.* Explain procedure of Powder preparation for the given 3D printing material. *TSO 1e.* Explain properties of the given Metal/Ceramics 3D printing material. *TSO 1f.* Choose suitable 3D printing material on the basis of Performance Requirements and Material Properties.	1.2 Popular FDM, SLA, SLS, Binder Jetting, Material Jetting and Direct Energy deposition 3D printing materials. 1.3 Polymers, Metals, Non-Metals, Ceramics. 1.4 Polymers and their properties. 1.5 Powder Preparation and their desired properties. 1.6 Choosing the Right 3D Printing Material on the basis of Performance Requirements and Material Properties.	
TSO 2a. Explain working of a typical FDM based 3D Printer. *TSO 2b.* Justify use of FDM based 3D printing process and material for the given component. *TSO 2c.* Explain the Laminated Object Manufacturing process. *TSO 2d.* Estimate the cost and time of the given FDM based 3D printed component.	**Unit-2.0 Solid based 3D Printing Processes** 2.1 Basic principle and working of fused deposition modeling (FDM) process. 2.2 Liquefaction, solidification and bonding. 2.3 Laminated Object Manufacturing process. 2.4 Cost estimation of FDM 3D printed component.	**CO1, CO2**
TSO 3a. Explain the phenomenon of Photo Polymerization. *TSO 3b.* Explain the working of a typical Stereo Lithography based 3D Printer. *TSO 3c.* Explain procedure of 3D Scanning of the given component. *TSO 3d.* Justify use of SLA based 3D printing process and material for the given component. *TSO 3e.* Estimate the cost and time of the given SLA based 3D printed component. *TSO 3f.* Apply Curing process to SLA based 3D printed component.	**Unit-3.0 Liquid based 3D Printing Processes** 3.1 Photo polymerization. 3.2 Principle and working of stereo lithography apparatus. 3.3 SLA based 3D printing processes. 3.4 SLA based 3D printing process materials. 3.5 Scanning techniques. 3.6 Curing processes. 3.7 Cost estimation of SLA 3D printed component.	**CO1, CO3**
TSO 4a. Explain powder fusion mechanism. *TSO 4b.* Explain working of a typical SLA based 3D Printer. *TSO 4c.* Justify use of SLA based 3D printing process and material for the given component. *TSO 4d.* Explain Net shape process. *TSO 4e.* Explain Binder Jet 3D printing process. *TSO 4f.* Justify use of Binder Jet 3D printing process and material for the given component. *TSO 4g.* Estimate the cost and time of the given SLS based 3D printed component.	**Unit-4.0 Powder based 3D Printing Processes** 4.1 Powder fusion mechanism. 4.2 Principle and working of Selective Laser Sintering (SLS) process. 4.3 SLS based 3D printers. 4.4 Laser Engineering Net Shaping process. 4.5 Electron Beam Melting. 4.6 Binder Jet 3D Printing. 4.7 Materials and Process parameters for SLS based 3D printing processes. 4.8 Cost estimation of SLS based 3D printed component.	**CO1, CO4**
TSO 5a. Justify the need of post processing in the given 3D printed component. *TSO 5b.* List the various post processing techniques. *TSO 5c.* List the steps to perform post processing.	**Unit-5.0 Post Processing and Quality** 5.1 Need of post processing: Functional and Aesthetic reasons.	**CO1, CO2, CO3, CO4, CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 5d. Explain the given Cleaning related post processing approach for 3D printed component. *TSO 5e.* Explain the given Surface finishing related post processing approach for 3D printed component. *TSO 5f.* Apply simple inspection and testing techniques on the given 3D printed component. *TSO 5g.* Identify the type of defect(s) in the given 3D printed component.	5.2 Steps of Post Processing: Cleaning/Support removal, Fixing, Curing or hardening, Surface finishing, Colouring. 5.3 Cleaning: Support Removal (FDM and Material Jetting); Powder Removal (SLS and Powder Bed Fusion); Washing (SLA and Photo polymerisation). 5.4 Fixing: Filling, Gluing, Welding. 5.5 Surface finishing: Sanding, Polishing, Tumbling, Hydro dipping, Epoxy coating, Electro Plating, Vapour smoothing-Acetone treatment. 5.6 Colouring, Coating, Priming and Painting. 5.7 Inspection and testing: Digital, Visual, Physical. 5.8 Defects and their causes.	

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400604E

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1. Use the available 3D printing software. *LSO 1.2.* Select printing process parameters based on the type/make of Printer and raw material *LSO 1.3.* Set printing process parameters. *LSO 1.4.* Produce a complex component using available FDM Printer.	1.	Develop the assigned digital single complex component using FDM based 3D Printer and available material.	CO1, CO2
LSO 2.1. Use the available 3D printing software. *LSO 2.2.* Select printing process parameters based on the type/make of Printer and raw material *LSO 2.3.* Set printing process parameters. *LSO 2.4.* Produce a complex component using available SLA Printer. *LSO 2.5.* Perform curing of the SLA based 3D printed component.	2.	Develop the assigned digital single complex component using SLA based 3D Printer and available material.	CO1, CO3
LSO 3.1 Use the available 3D printing software. LSO 3.2 Select printing process parameters based on the type/make of Printer and raw material LSO 3.3 Set printing process parameters. LSO 3.4 Produce a complex component using available SLS Printer.	3.	Develop the assigned digital single complex component using SLS based 3D Printer and available material.	CO1, CO4
LSO 4.1. Use the available 3D printing software. *LSO 4.2.* Select printing process parameters based on the type/make of Printer and raw material *LSO 4.3.* Set printing process parameters. *LSO 4.4.* Produce a complex component using available FDM, SLA and SLS Printer.	4.	Develop same digital single complex component using FDM, SLA and SLS based 3D Printers and compare the printed components on the basis of Cost, Time, Surface finish, Strength.	CO1, CO2, CO3, CO4

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 4.5. Perform Cost, Time, Surface finish and Strength estimations related to 3D printed components.			
LSO 5.1. Use the available 3D printing software. *LSO 5.2.* Select printing process parameters based on the type/make of Printer and raw material *LSO 5.3.* Select appropriate tolerance, fit and printing process parameters. *LSO 5.4.* Produce an assembly using available SLA/SLS Printer.	5.	Print one digital assembly on SLA/SLS based 3D Printer.	CO2/CO3/ CO4
LSO 6.1. Use of available 3D scanner. *LSO 6.2.* Develop 3D digital model using scanning approach. *LSO 6.3.* Use the available 3D printing software. *LSO 6.4.* Produce a complex component using available SLA Printer.	6.	Scan the given real complex component and print it using FDM/SLA/SLS based 3D Printer.	CO2, CO3, CO4
LSO 7.1. Identify tools/devices/chemicals for post processing *LSO 7.2.* Perform post processing operations on printed component.	7.	Apply post processing techniques on the 3D printed component of experiment number 1 and/or 2 and/or 3.	CO5
LSO 8.1. Identify tools/devices/techniques for inspection and testing. *LSO 8.2.* Identify the defects in 3D printed components *LSO 8.3.* Apply remedial measures to bring soundness in the defective 3D printed component.	8.	Check the soundness of the 3D printed component of experiment number 1 and/or 2 and/or 3 using available devices/techniques.	CO5

L) Suggested Term Work and Self Learning: S2400604E Some sample suggested assignments, micro project and other activities are mentioned here for reference

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

b. Micro Projects:

1. Prepare a list of solid, liquid and powder form 3D printing raw materials stating their cost, colour opacity, flexibility and weight per unit volume.
2. Download 5 videos of 3D printing of different components using FDM, SLA and SLS each. Watch them and write a report to detail out the steps involved, 3D Printer used, 3D Printing software used, material used, complexity involved, printing time, post processing steps used.
3. Prepare a report on post processing steps and techniques used for 3D printed components using FDM, SLA, SLS.
4. Prepare a report to compare FDM, SLA, SLS based 3D printing process on the basis of cost, surface finish, printer setting time, printing time and post processing time and cost involved.
5. Download 5 videos of 3D printing processes other than FDM, SLA and SLS. Watch them and write a report to detail out the steps involved, 3D Printer used, 3D Printing software used, material used, complexity involved, printing time, post processing steps used.

6. Download 1 video related to inspection and testing of 3D printed components using different techniques like Visual inspection, Scanning Electron Microscopy (SEM), CT system, X-ray, Penetration testing, Infrared thermography, Leak or pressure testing for complex structures, Eddy current, Mechanical property inspection to measure tensile, yield, shear, fatigue, hardness, density, impact strength, Metallography (Microstructure testing). Watch them and write a report to detail out the steps involved and equipment used.

c. Other Activities:

i. Seminar Topics:
- Newer 3D printing raw materials
- Direct energy 3D printing process
- Material jetting 3D printing process
- Micro 3D printing process
- Metal and Ceramic 3D printing
- 3D printing of Jewelry
- 3D printing of Bio implants
- Printing of flexible plastic components

ii. Visits: Visit nearby tool room/industry with 3D Printing facilities. Prepare report of visit with special comments of 3D printing technique used, material used, single component/batch production/mass production and cost of printed component.

iii. Self-Learning Topics:
- 3D printing of transparent, soft and flexible plastic components
- 3D printing of metal components
- 3D printing of ceramic components
- 3D scanning process.
- Chemical post processing techniques

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

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%	-	-	10%	20%
CO-2	20%	20%	20%	25%	25%	25%	20%
CO-3	20%	20%	20%	25%	25%	25%	20%
CO-4	20%	20%	20%	25%	25%	25%	20%
CO-5	25%	25%	25%	25%	25%	15%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

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

Note:
- The percentages given are approximate.
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.

- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

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

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 3D Printing Materials	6	CO1	10	3	2	5
Unit-2.0 Solid based 3D Printing Processes	10	CO1, CO2	14	4	5	5
Unit-3.0 Liquid based 3D Printing Processes	10	CO1, CO3	14	4	5	5
Unit-4.0 Powder based 3D Printing Processes	10	CO1, CO4	14	4	5	5
Unit-5.0 Post Processing and Quality	12	CO1, CO2, CO3, CO4, CO5	18	5	5	8
Total	**48**	**-**	**70**	**20**	**22**	**28**

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Develop the assigned digital single complex component using FDM based 3D Printer and available material.	CO1, CO2	30	60	10
2.	Develop the assigned digital single complex component using SLA based 3D Printer and available material.	CO1, CO3	30	60	10
3.	Develop the assigned digital single complex component using SLS based 3D Printer and available material.	CO1, CO4	30	60	10
4.	Develop same digital single complex component using FDM, SLA and SLS based 3D Printers and compare the printed components on the basis of Cost, Time, Surface finish, Strength.	CO1, CO2, CO3, CO4	30	60	10
5.	Print one assembly on SLA/SLS based 3D Printer.	CO2/CO3/ CO4	30	60	10
6.	Scan the given real complex component and print it using FDM/SLA/SLS based 3D Printer.	CO2, CO3, CO4	40	50	10
7.	Apply post processing techniques on the 3D printed component of experiment number 1 and/or 2 and/or 3.	CO5	40	50	10
8.	Check the soundness of the 3D printed component of experiment number 1 and/or 2 and/or 3 using available devices/techniques.	CO5	40	50	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	High end computers	Processor Intel Core i7 with Open GL Graphics Card, RAM 32 GB, DDR3/DDR4, HDD 500 GB, Graphics Card NVIDIA OpenGL 4 GB, OS Windows 10	All
2.	Parametric Computer Aided Design software	CATIA/Solid works/NX/Creo **OR** Available with CoE	1 to 5
3.	FDM based 3D printer	Fused Deposition Modelling system with complete accessories; Build Volume-300 x 300 x 300mm or Higher; Layer Thickness-0.1 – 0.4 **OR** Available with CoE	1,4,5,6
4.	SLA based 3D printer	Printing Technology: SLA, 145 x 145 x 175mm build volume, Common layer thickness 25–100 µm, Dimensional Accuracy ± 0.5% (lower limit: ±0.10 mm), cure time of only 1-3s per layer, Material type: UV-sensitive liquid resin, Curing unit.	2,4,5,6
5.	SLS based 3D printer	Printing Technology: SLS., Build Volume: 130 x 130 x 180 mm, Recommended min. wall thickness: 0.8 mm, Powder Diameter: 60 Microns, Material Type: Nylon, TPU, Light Source: Laser Diode	3,4,5,6
6.	3D Printing Material	ABS/PLA, Resin based Photosensitive material, Polymer/metal/ceramic powder **OR** Available with CoE	1,2,3,4,5,6
7.	3D Printing software	Latest version of software like: Cura/PrusaSlicer/ideaMaker/Meshmixer/MeshLab **OR** Available with CoE	1 to 6
8.	3D Scanner and Processing software	Handheld 3D scanner, Accuracy up to 0.1 mm, Resolution up to 0.2 mm, Real time onscreen 3D model projection and processing, Wireless technology with an inbuilt touch screen and battery, Extended field of view for capturing both large and small objects, Processing Software **OR** Available with CoE	6
9.	Post processing equipments and tools	Deburring tools (tool handle & deburring blades), Electronic Digital Caliper, Cleaning Needles, Art knife set, Long nose pliers, Flush cutters, Wire brush, Nozzle cleaning kit, Tube cutter, Print removal spatula, Needle file, Cutting mat, Glue stick, Wire stripper, Chemicals, Etching agents etc.	7
10.	Inspection and Testing devices	• Visual inspection, Devices related to: • Scanning electron microscopy (SEM), CT system, X-ray, • Penetration testing, • Infrared thermography, • Leak or pressure testing for complex structures, • Eddy current, • Mechanical property inspection to measure tensile, yield, shear, fatigue, hardness, density, impact strenght • Metallography (Microstructure testing)	8

R) Suggested Learning Resources:

(b) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing	Lan Gibson, David W. Rosen, Brent Stucker	Springer, 2010 ISBN: 9781493921133
2.	Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing	Andreas Gebhardt,	Hanser Publisher, 2011 ISBN: 156990507X, 9781569905074
3.	3D Printing and Design	Sabrie Soloman	Khanna Publishing House, Delhi ISBN: 9789386173768
4.	3D Printing and Rapid Prototyping- Principles and Applications	C.K. Chua, Kah Fai Leong	World Scientific, 2017 ISBN: 9789813146754
5.	Getting Started with 3D Printing: A Hands-on Guide to the Hardware, Software, and Services Behind the New Manufacturing Revolution	Liza Wallach Kloski, Nick Kloski	Make Community, LLC; 2nd edition, 2021 ISBN: 9781680450200
6.	Laser-Induced Materials and Processes for Rapid Prototyping	L. Lu, J. Fuh, Y.S. Wong	Kulwer Academic Press, 2001 ISBN: 9781461514695

(b) Online Educational Resources:

1. https://onlinecourses.nptel.ac.in/noc21_me115/preview
2. https://archive.nptel.ac.in/courses/112/104/112104265/
3. https://bigrep.com/post-processing/
4. https://www.mdpi.com/2227-7080/9/3/61
5. https://all3dp.com/2/best-3d-printing-books/
6. https://www.youtube.com/watch?v=TQY2lF-sFaI
7. https://www.youtube.com/watch?v=Oz0PoS5LPxg
8. https://www.youtube.com/watch?v=6ejjh0GdyDc

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

(c) Others:

1. 3D Printing Projects DK Children; Illustrated edition, 2017
2. The 3D Printing Handbook: Technologies, design and applications Ben Redwood, Filemon Schöffer, Brian Garret, 3D Hubs; 1st edition, 2017
3. https://www.improprecision.com/inspection-method-for-3d-printed-parts/
4. 3D Printer Users' Guide
5. 3D Printer Material Handbook
6. Lab Manuals

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A) Course Code : **2400604F(T2400604F/P2400604F/S2400604F)**

B) Course Title : Industrial Automation (Advance)

C) Pre- requisite Course(s) : Industrial automation (Basic), Digital Electronics and Basic programming skills

D) Rationale :

This course on Advanced industrial automation offers students a hands-on approach to implement industrial control using modern controllers like Programmable Logic Controller (PLC), Distributed Control System (DCS)Supervisory Control and Data Acquisition (SCADA). Students will learn to identify and connect field inputs and outputs; communicate with, and program microprocessor-based controllers. Students will also connect, communicate with, and develop displays for computer-based operator interfaces. Process manufacturers typically employ Distributed Control System (DCS) Supervisory Control and Data Acquisition (SCADA) technologies to monitor and control the operations in their facilities. DCS and SCADA systems are now doing much more than simply monitoring and controlling. The course will enable the students to use of basic instructions and addressing, advanced PLC instructions in Ladder Logic and to identify and troubleshoot the faults in PLC system and do PLC maintenance. This course also introduces the students to industrial automation communications, PLC maintenance and troubleshooting also to become a successful automation engineer.

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

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

CO-1. Apply the principles of communication for industrial automation.

CO-2. Test the output of the PLC ladder logic programs for the given application

CO-3. Maintain PLC systems

CO-4. Use SCADA for supervisory control and for acquiring data from the field.

CO-5. Develop simple automation systems

F) Suggested Course Articulation Matrix (CAM):

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

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

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

G) Teaching & Learning Scheme:

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				
2400604F	Industrial Automation (Advance)	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:

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)	
2400604F	Industrial Automation (Advance)	30	70	20	30	20	30	200

Legend:

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

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

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: T2400604F

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.1a Describe how does a PLC communicate? TSO.1b Differentiate between parallel and series communication TSO.1c Describe the data transfer mechanism for the given communication protocols. TSO.1d Describe the given communication protocol used in PLC communication. TSO.1e Summarize PLC to PLC communication procedure TSO.1f Describe the common procedure to interface the PLC with other given hardware.	**Unit-1.0 Industrial automation communication and Interfacing** 1.1 Analog and Digital Communications on Plant Floors 1.2 Introduction to Industrial Networking 1.3 RS232-422-485 standards for data communication 1.4 Industrial Ethernet 1.5 Concept of Fieldbus 1.6 MODBUS protocol 1.7 Highway Addressable Remote Transducer (HART) Protocol 1.8 Interfacing of Programmable Logic Controller with other hardware	**CO-1**
TSO.2a Specify the proper I/O addressing format of the given PLC. TSO.2b Explain the use of different relay type instructions for the given operation. TSO.2c Describe how a program is executed with the help of Program Scan cycle TSO.2d Develop ladder logic program using arithmetic functions to perform the given operation. TSO.2e Develop ladder logic programs using logical and comparison instructions to perform the given operation TSO.2f Develop ladder logic programs using on delay, off delay and reset/retentive timer in a given PLC to create a delay in operation. TSO.2g Develop ladder logic programs using Up, Down and UP-down counter in a given PLC to count the number of products	**Unit-2.0 PLC Programming** 2.1 PLC I/O addressing in ladder logic 2.2 PLC programming instructions using ladder logic and relay type instructions 2.3 Program Scan cycle 2.4 PLC arithmetic functions - Addition, subtraction, multiplication, division instructions, increment decrement, trigonometric 2.5 PLC logical functions - AND, OR, XOR, NOT functions, PLC compare and convert functions. 2.6 Programming Timer –Addressing a timer block, status bits, On delay, Off Delay and reset/retentive timer 2.7 Programming Counter- Addressing a counter block, status bits, Up and Down counter, up-down counter, counter examples, register basics 2.8 Develop ladder logic for various simple applications	**CO-2**
TSO.3a Describe Requirements for PLC enclosure. TSO.3b Describe Proper grounding techniques. TSO.3c Describe noise reduction Techniques. TSO.3d Explain preventive maintenance procedure associated with PLC system to reduce environmental impact TSO.3e Identify faults in the given PLC system TSO.3f Explain the procedure for Troubleshooting PLC system TSO.3g Prepare preventive maintenance plan for the PLC system	**Unit-3.0 Installation and maintenance of PLC systems** 3.1 PLC enclosure, grounding requirements, noise generating inductive devices, leaky inputs and outputs, techniques to reduce electrical noise and leakage. 3.2 Introduction to PLC Trouble shooting and maintenance, trouble shooting of hardware and software. 3.3 Diagnostic LED Indicators in PLCs 3.4 Common problems • Internal problems – Check for PLC Power Supply, Emergency Push Button, Power Supply Failure, Battery Failure, Electrical Noise Interference, Verify the PLC Program with the Master Program, Corrupted PLC Memory • External problems - Power failure, faulty grounding and electrical noise interference (RFI or EMI),	**CO-3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.3h Use safety equipment's. TSO.3i Follow safe practices	Status of the Output Modules and their associated Circuitry, Status of the Input Modules and their associated Circuitry, Field Input and Output Devices, Communication Issues. • Environmental Conditions. Check for humidity, temperature, vibration, and noise-level limits specified by its manufacturer 3.5 Troubleshooting of Specific Components of the PLC System • Power Supply Troubleshooting • I/O Modules Troubleshooting • Troubleshooting PLC Program Errors • Troubleshooting the Working Environment of a PLC • Replacement of CPU 3.6 PLC trouble shooting flowchart 3.7 PLC maintenance – PLC maintenance checklist, preventive maintenance procedure, maintenance plan for the PLC system. 3.8 Safety procedure and safety equipment's.	
TSO.4.a Describe the function of given element of a SCADA system. TSO.4.b Interface the given PLC with SCADA system using the given Open Platform Communications (OPC). TSO.4.c Describe the steps to develop a simple SCADA screen for the given industrial application. TSO.4.d Describe the procedure to maintain the SCADA based PLC system for the given application.	**Unit-4.0 SCADA and DCS** 4.1 Introduction, need, benefits and typical applications of SCADA and DCS 4.2 SCADA Architecture - Remote Terminal Units (RTUs), Master Terminal Units, Various SCADA editors, Communication protocols for SCADA 4.3 Comparison of SCADA with DCS 4.4 Interfacing SCADA system with PLC- Typical connection diagram, Object Linking and Embedding for Process Control (OPC) architecture 4.5 Creating SCADA Screen HMI for simple object, Steps for linking SCADA object (defining Tags and items, creating trends etc.,) with PLC ladder program using OPC, configuring simple applications using SCADA: Traffic light control, water distribution, pipeline control, Power generation, transmission and distribution etc. 4.6 Procedure to maintain the SCADA based PLC system.	**CO-3**
TSO.5a Identify different components used for automation in the given system TSO.5b Select automation components for a given situation TSO.5c In the given manufacturing or service industry Identify the areas where automation is possible. TSO.5d Prepare plan for sustainable automation as per the requirement.	**Unit-5.0 Applications of Industrial Automation** 5.1 **Manufacturing-** Industrial Robots- welding robots, pick and place robots, Cabot's, Machine monitoring system, supply chain, Automated assembly system, Flexible Automation and programmable Automation. 5.2 **Health Care-** microscopic robots for medical diagnosis, automated medication dispensing devices, AESOP, ZEUS, RP_7(remote presence 7th generation), DaVinci 5.3 **Defense- guided rockets and missiles,** counter measures, UAV drones, launcher, radar antenna, engagement control system 5.4 **Automobile –B**reak monitoring system, Vehicle tracking system, Rear-view alarm to detect obstacles behind, Four-wheel drive, Traction control system, Dynamic steering response, Anti-lock braking system (ABS) Adaptive cruise control, Adaptive headlamps,	**CO-5**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
	Intelligent Parking Assist System, Driverless/Autonomous Cars 5.5 **Agriculture-** harvesters, irrigation systems, plowing machines, self-driving tractors, grain yield sensor 5.6 **Mining-** Mine planning system, mine picture compilation, mine control system, seismic imagining, laser imaging, Rig control system, automated drilling, automated exploration, automated truck	

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400604F

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Data communication from PLC to PC and vice versa	1.	Transfer the control data from PLC to PC and vice versa	CO1
LSO 1.2 Establish Communication channels between PLC s.	2.	Transfer the control data from PLC to PLC	CO1
LSO 1.3 Transfer data from sensors to PLC and from PLC to PC.	3.	Transfer the sensor data from sensor to PLC to PLC and PC	CO1
LSO 1.4 Interface the given PLC with a PC or a Laptop	4.	Interface the given PLC with a PC or a Laptop	CO1
LSO 2.1 Identify Different parts and front panel indicators of a PLC	5.	Identify the various parts and front panel status indicators of the given PLC.	CO2
LSO 2.2 Develop Ladder logic program for different arithmetic operations	6.	Develop/Execute ladder logic program for different arithmetic operations such as Addition, subtraction, multiplication, division increment, decrement, trigonometric in a given PLC	CO2
LSO 2.3 Develop Ladder logic program for different logical operations	7.	Develop/Execute ladder logic program for logical operations such as AND, OR, NOT, NAND, NOR, X-OR, X-NOR gate along with truth table	CO2
LSO 2.4 Program Latch and Unlatch circuit in a PLC for motor operation	8.	Program the given PLC to start run and stop the given motor using latch circuit	CO2
LSO 2.5 Create delay in operation using on delay, off delay and retentive timer function in a given PLC.	9.	Test the functionality of on delay, off delay and retentive timer for its correct operation in a given PLC.	CO2
LSO 2.6 Count the number of objects/events using Up counter, Down counter and UP/Down counter in a PLC	10.	Test the functionality of Up, Down and Up-down counter for its correct operation in a given PLC.	CO2
LSO 2.7 Program PLC using ladder logic to control a LED/Lamp	11.	Develop/Execute a ladder logic program to put LED/lamp in the blinking mode	CO2
LSO 2.8 Program PLC using ladder logic to control a simple traffic light system	12.	Develop/Execute a ladder logic program to control a simple traffic light control system using PLC	CO2
LSO 3.1 Use hygrometer to measure the humidity inside the panel *LSO 3.2* Use thermometer to measure ambient temperature inside the panel *LSO 3.3* Use tester to determine the voltage fluctuation at the power supply terminals is within specifications	13.	Troubleshooting of PLC system	CO3

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 3.4 Test the ground connections of the given PLC. *LSO 3.5* A given PLC is not working as per the logic instructions investigate the PLC to identify the cause of failure to show the desired output *LSO 3.6* Investigate the cause of Noise in the given PLC *LSO 3.7* PLC goes on blackout out by losing its operating power. Troubleshoot the cause of failure. *LSO 3.8* Troubleshoot the corrupted PLC memory. *LSO 3.9* Replace CPU and power supply fuses in a given PLC system.			
LSO 4.1 Download any opensource SCADA software and install the same. *LSO 4.2* Interpret the available components in symbol factory of SCADA software *LSO 4.3* Create simple SCADA HMI applications and apply dynamic properties. (Select any Three from the given list) i. Turn on and off a tube light using a Switch ii. Apply filling and object size properties to a rectangle, square and round object iii. Move the object, fill the object using slider and meter reading. iv. Apply orientation property to a fan and control its direction using a slider. v. Move a square object horizontally first, then vertically and again horizontally by applying visibility property. *LSO 4.4* Create historical and real time trends for the given automation	14.	Develop simple SCADA HMI applications using any one opensource SCADA software and apply dynamic properties	CO4
LSO 5.1 Develop a smart irrigation device to detect the change in moisture level in the soil and controls the flow of water accordingly with a DC pump. *LSO 5.2* Build an electronic device that can remotely control home appliances with your Bluetooth-enabled smartphone and a special Android application *LSO 5.3* Develop a PLC program to control the robot in such a way that the robot can automatically pick and place components and works in sync with the conveyor belt system. *LSO 5.4* Develop an Automation system to Open and close the door in the shop	15.	Develop simple automation systems for the given requirement (Select any Three from the given list)	CO5

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 5.5 Develop a line following robot with RFID sensor for supplying materials and automating workflow. *LSO 5.6* Develop smart street light controlling mechanism which will Switch on/off the lights automatically depending on the intensity of the sunlight at that particular time of the day. *LSO 5.7* Develop smart automated railway crossing system to detect train arrival and departure and send appropriate signals to the microcontroller.			

L) Suggested Term Work and Self Learning: S2400604F Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

i. State three advantages of using programmed PLC timer over mechanical timing relay.
ii. It is required to have a pilot light glow, meeting all of the circuit requirements given below:
   - All four circuit pressure Switches must be closed.
   - At least two out of three circuit limit Switches must be closed.
   - The reset Switch must not be closed.
iii. Using AND, OR, and NOT gates, design a logic circuit that will solve this hypothetical problem
iv. Prepare a comparison chart of different types of PLC
v. Prepare a maintenance plan for a given PLC system.

b. Micro Projects:

1. Troubleshoot the faulty equipment/kit available in automation laboratory
2. Select one industry and analyze the process and propose the automation strategies' that can be used for automation.
3. Develop a working model of a given application using given actuators and valves.
4. Develop a smart irrigation device to detect the change in moisture level in the soil and controls the flow of water accordingly with a DC pump.
5. Build an electronic device that can remotely control home appliances with your Bluetooth-enabled smartphone and a special Android application
6. Develop a PLC program to control the robot in such a way that the robot can automatically pick and place components and works in sync with the conveyor belt system.

c. Other Activities:

1. Seminar Topics- PLC instructions, Timers and Counters used in a given PLC
2. Seminar Topics- Industrial Applications of PLC and SCADA, AGV, Application of automation in different area, trouble shooting of different types of PLC
3. Visits – Visit any industry with full or semi automation and prepare a report on industrial automation used by the industry in the given section, components used, power requirement, output achieved and maintenance activities required.
4. Surveys- Carry out a market/internet survey of PLC and prepare the comparative technical specifications of any one type of PLC (Micro or Mini) of different manufacturer.

5. Product Development- Develop a prototype automatic railway crossing system

a. Software Development- Download any open source software for PLC and install on your laptop/PC and carry out basic PLC programming

6. Also download any open source software for SCADA and install on your laptop/PC and carry out basic SCADA HMI programming
7. Surveys – Carry out an internet based survey to compare SCADA and DCS

d. Self-Learning Topics:

- Basic concepts of working of robot
- Automated material handling.
- Instrumentation systems for inspection and testing for quality of the product
- Use of robots in different applications
- Intelligent Transportation Systems
- Communication standards and protocols used in PLC
- Use of PLC for different industrial applications
- Use of SCADA for different industrial applications
- Interfacing of PLC

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

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self-Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	10%	20%	20%	--	33%	10%	20%
CO-2	15%	25%	20%	--	33%	15%	20%
CO-3	15%	20%	20%	--	34%	15%	20%
CO-4	30%	20%	20%	50%	--	30%	20%
CO-5	30%	15%	20%	50%	--	30%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

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

****:** Mentioned under point- (N)

#: Mentioned under point- (O)

Note:

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

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

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-.1.0 Industrial automation Communication and Interfacing	9	CO1	14	5	4	5
Unit-.2.0 PLC Programming	12	CO2	17	5	6	6
Unit-.3.0 Installation and maintenance of PLC systems	10	CO3	14	4	5	5
Unit-.4.0 SCADA and DCS	9	CO4	14	4	5	5
Unit-.5.0 Applications of Industrial Automation	8	CO5	11	2	4	5
Total Marks	**48**		**70**	**20**	**24**	**26**

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Transfer the control data from PLC to PC and vice versa	CO1	50	40	10
2.	Transfer the control data from PLC to PLC	CO1	50	40	10
3.	Transfer the sensor data from sensor to PLC to PLC and PC	CO1	50	40	10
4.	Interface the given PLC with a PC or a Laptop	CO1	50	40	10
5.	Identify Different parts and front panel indicators of a PLC	CO2	50	40	10
6.	Develop Ladder logic program for different arithmetic operations	CO2	50	40	10
7.	Develop Ladder logic program for different logical operations	CO2	50	40	10
8.	Program Latch and Unlatch circuit in a PLC for motor operation	CO2	50	40	10
9.	Create delay in operation using on delay, off delay and retentive timer function in a given PLC	CO2	50	40	10
10.	Count the number of objects/events using Up counter, Down counter and UP/Down counter in a PLC	CO2	50	40	10
11.	Program PLC using ladder logic to control a LED/Lamp	CO2	50	40	10
12.	Program PLC using ladder logic to control a simple traffic light system	CO2	50	40	10

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
13.	Use hygrometer to measure the humidity inside the panel	CO3	50	40	10
14.	Use thermometer to measure ambient temperature inside the panel	CO3	50	40	10
15.	Use tester to determine the voltage fluctuation at the power supply terminals is within specifications	CO3	50	40	10
16.	A given PLC is not working as per the logic instructions investigate the PLC to identify the cause of failure to show the desired output	CO3	50	40	10
17.	Investigate the cause of Noise in the given PLC	CO3	50	40	10
18.	PLC goes on blackout out by losing its operating power. Troubleshoot the cause of failure.	CO3	50	40	10
19.	Troubleshoot the corrupted PLC memory.	CO3	50	40	10
20.	Replace CPU and power supply fuses in a given PLC system	CO3	50	40	10
21.	Download any open source SCADA software and install the same.	CO4	50	40	10
22.	Interpret the available components in symbol factory in SCADA software	CO4	50	40	10
23.	Create simple SCADA HMI applications and apply dynamic properties **(Any Three).** i. Turn on and off a tube light using a Switch ii. Apply filling and object size properties to a rectangle, square and round object iii. Move the object, fill the object using slider and meter reading. iv. Apply orientation property to a fan and control its direction using a slider. v. Move a square object horizontally first, then vertically and again horizontally by applying visibility property.	CO4	50	40	10
24.	Create historical and real time trends for the given automation	CO4	50	40	10
24	**Select any three of the following: -** i. Develop a smart irrigation device to detect the change in moisture level in the soil and controls the flow of water accordingly with a DC pump. ii. Build an electronic device that can remotely control home appliances with your Bluetooth-enabled smartphone and a special Android application iii. Develop a PLC program to control the robot in such a way that the robot can automatically pick and place components and works in sync with the conveyor belt system. iv. Develop a Automation system to Open and close the door in the shop v. Develop a line following robot with RFID sensor for supplying materials and automating workflow. vi. Develop smart street light controlling mechanism which will Switch on/off the lights automatically depending on the intensity of the sunlight at that particular time of the day.	CO5	60	30	10

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
	vii. Develop smart automated railway crossing system to detect train arrival and departure and send appropriate signals to the microcontroller.				

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

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	SCADA software (reputed make like Allen Bradley, Siemens etc.,)	Ready-to-use symbol library, React and respond in real-time, Real time monitoring, Friendly, manageable, secure, extensible, Easy-to-use, easy to implement, Easy configuration, simplified maintenance, Communication with PLC, easy and flexible alarm definition, data collection and analysis for new and existing systems, easy-to-use for report generation, open access to historical data, different packages available with input/output structure. Open source software SCADA software: like Ellipse/FTVSE/Wonderware/ open SCADA can also be used	14
2.	Universal PLC Training System with HMI (Of reputed make such as Allen bradely, Siemens, etc.,) Compatible with SCADA software	Human Machine Interface (HMI) display, PLC with 16 digital inputs, 16 digital outputs with RS232 communication facility. Open platform to explore wide PLC and HMI applications. Industrial look & feel. Toggle Switches, push to ON Switch, proximity sensor, visual indicator, audio indicator, and DC motor. Experiments configurable through patch board. Powerful instruction sets. Several sample ladder and HMI programs. PC based ladder and HMI programming. Extremely easy and student friendly software to develop different programs. Easy downloading of programs. Practice troubleshooting skills. Compact tabletop ergonomic design. Robust construction. PLC gateway for cloud connectivity. Open source software like Ladder logic simulator, Pico soft Simulator, Logixpro simulator, Simple EDA tools can also be used	1 to 12
3.	Safety gears	Gloves, Safety goggles, Ear protection, Dust masks and respirators.	13
4.	Power tools	Power drills, Orbital sanders, Circular saws, Impact wrenches.	13
5.	Hand tools	Screwdrivers, Hammers, Hand saws, Hex Key Allen Wrench Set Inch and Metric, relay puller, Multi-Tool Wire Stripper/Crimper/Cutter	13

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
6.	Electrical tools	Wire and cable strippers, Multimeters- Volts, Ohms, and Amps, Crimpers- Side Cutter Crimping, Wire Crimp Connector Kit, Digital Multimeter Clamp Meter with Amp, Volt, and Ohm, Non-Contact Voltage Tester	13
7.	Spare parts	PLC Programming Cables, SD Card Reader Compact flash, Wire Nut Set, Fuses- Class J 30, 35, 60, and 100-amp fuses, Class CC 2, 3, 5, 10 ,15, 20, and 30-amp fuses, 5mm x 20mm 0.032 (for 4-20mA circuits), 0.5, 1, 2, 5, 10, and 15 amps, Cube Relays, Resistor Kit, batteries, LED Indicators PLC Processor (CPU), Input/ output module	13
8.	Thermo-hygrometer	Measuring range Temp.: -30 ... 60°C / -22 ... 140°F Measuring range rel. Humidity: 0 ... 100% rh, Measurement protocol as PDF, Data export possible as CSV, Readable without software, data sets of measured values can be stored.	13
9.	Digital Hygrometer	maximum humidity measurement- 100%RH, temperature measurement resolution -0.1egree centigrade, humidity measurement resolution -0.1%RH, minimum operating temperature - -10 to -20-degree centigrade, Maximum operating temperature +45 to +50 degree centigrade	13

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
9.	Introduction to Programmable Logic Controllers	Dunning, G.	Thomson /Delmar learning, New Delhi, 2005, ISBN 13: 9781401884260
10.	Programmable Logic Controllers	Petruzella, F.D.	McGraw Hill India, New Delhi, 2010, ISBN: 9780071067386
11.	Programmable Logic Controllers	Hackworth, John; Hackworth, Federic	PHI Learning, New Delhi, 2003, ISBN: 9780130607188
12.	Industrial automation and Process control	Stenerson Jon	PHI Learning, New Delhi, 2003, ISBN: 9780130618900
13.	Programmable Logic Controller	Jadhav, V. R.	Khanna publishers, New Delhi, 2017, ISBN: 9788174092281
14.	Programmable Logic Controllers and Industrial Automation - An introduction,	Mitra, Madhuchandra; Sengupta, Samarjit,	Penram International Publication, 2015, ISBN: 9788187972174
15.	Control System	Nagrath & Gopal	New Age International Pvt Ltd, ISBN: 9789386070111, 9789386070111
16.	Linear Control Systems with MATLAB Applications, Publisher:	Manke, B. S.	Khanna Publishers, ISBN: 9788174093103, 9788174093103
17.	Supervisory Control and Data Acquisition	Boyar, S. A.	ISA Publication, USA, ISBN: 978-1936007097
18.	Practical SCADA for industry,	Bailey David; Wright Edwin	Newnes (an imprint of Elsevier), UK 2003, ISBN:0750658053

(b) Online Educational Resources:

1. Software: - www.fossee.com
2. Software: - www.logixpro.com
3. Software: - www.plctutor.com
4. Software; - www.ellipse.com
5. PLC lecture: - https://www.youtube.com/watch?v=pPiXEfBO2qo
6. PLC tutorial: http://users.isr.ist.utl.pt/~jag/aulas/apil3/docs/API_I_C3_3_ST.pdf
7. https://www.youtube.com/watch?v=277wwYWolpw-PLC system troubleshooting and repair. Industrial control panel. PLC system repair.
8. https://www.youtube.com/watch?v=5Jmtvrch5Jg
9. https://www.youtube.com/watch?v=peyV9bwEaLY
10. https://www.youtube.com/watch?v=QdJhRmtKpxk&list=RDCMUCke36Liq-w5fboMHkq1APZw&index=3
11. https://www.youtube.com/watch?v=ygrrRwaJz3M

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

(c) Others:

1. Learning Packages
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

*****

A) Course Code : **2400604G(T2400604G/P2400604/S2400604G)**

B) Course Title : Electric Vehicle (Advance)

C) Prerequisite Course(s) : Electric Vehicle (Basics)

D) Rationale :

The automobile manufacturing sector in India is rapidly switching over to electric vehicles used for the public as well as private transport. The Govt. of India has launched the FAME-II Scheme (Faster Adoption and Manufacturing of Hybrid & Plug-in Electric Vehicles) to encourage the progressive induction of reliable, affordable and efficient electric and hybrid vehicles and to create demand for Electric Vehicles in the country. The technology is being evolved to enhance the vehicle's efficiency and running mileage by controlling the manufacturing, maintenance and recurring costs of such vehicles. Due to the rapid increase in EV demand, industries will also require skilled manpower in this area. This advanced course on electric vehicles is included as an open elective for all the diploma programmes to provide a sound knowledge of EVs to engineering diploma students and develop skills related to testing and maintenance of various electrical, electronic and mechanical systems in EVs.

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

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

- **CO-1** Compute various parameters affecting Vehicle movement.
- **CO-2** Test the operation of the different elements of the Automobile System.
- **CO-3** Test the battery and motor used for Power Transmission in EVs.
- **CO-4** Test electronic control unit system of EVs.
- **CO-5** Interpret the impact of Grid to Vehicle (G2V) and Vehicle to Grid (V2G) during the charging cycle.

F) Suggested Course Articulation Matrix (CAM):

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

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

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

G) Teaching & Learning Scheme:

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				
2400604G	Electric Vehicle (Advance)	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:

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)	
2400604G	Electric Vehicle (Advance)	30	70	20	30	20	30	200

Legend:

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

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

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

J) Theory Session Outcomes (TSOs) and Units: T2400604G

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain the vehicle movement process TSO 1b. Derive various equations for the movement of Vehicles TSO 1c. Compute different resistances affecting Vehicle movement. TSO 1d. Explain the dynamics of the given type of EV system.	**Unit-1.0 Vehicle Dynamics** 1.1 Vehicle Movement 1.2 Rolling Resistance: Equation, Coefficient, factor affecting rolling resistance, typical values of rolling resistance 1.3 Grading resistance 1.4 Road resistance 1.5 Acceleration resistance 1.6 Total driving resistance 1.7 Aerodynamic drag: Equation, typical values of the drag coefficient. 1.8 Vehicle dynamics • Hybrid and Electric Vehicles • DC Motor Dynamics and Control • AC Motor Dynamics and Control	**CO1**
TSO 2 a. Identify the given elements of Automobile Systems. TSO 2 b. Describe the functions of the given elements of Automobile Systems. TSO 2 c. Explain the dynamic characteristics of the Disc Braking System for the given braking steps. TSO 2 d. Describe the Procedure for testing the given AC/DC motors. TSO 2 e. Describe the Procedure of Installation and Testing of the given EV Charging Stations. TSO 2 f. Describe the Procedure for Commissioning EV Charging Stations. TSO 2 g. Explain the functions of the EV Control Unit.	**Unit-2.0 Elements of Automobile** 2.1 Suspension and Damping systems 2.2 Brake system: Half-step braking, Full step Braking 2.3 Transaxle 2.4 Elements of Noise Vibration and Harshness Control 2.5 Body balancing 2.6 Tyre Technology 2.7 AC/DC motor 2.8 Air-conditioning and Heating System 2.9 Lighting System 2.10 Automotive wiring system 2.11 Earthing and Insulation 2.12 Charging stations – Installation and Commissioning 2.13 Vehicle control unit	**CO2**
TSO 3a. Compare different power transmission systems in EVs. TSO 3b. List the main Components of the EV Power Train. TSO 3c. Explain the functions of the given EV Power Train component. TSO 3d. Describe the testing procedure of the given EV Power Train component. TSO 3e. Explain the regenerative braking operation in the given EV motor. TSO 3f. Describe the speed control mechanism of the given motor. TSO 3g. Explain various parameters of the given battery. TSO 3h. Select the suitable battery for the given EV application. TSO 3i. Describe the assembling and dismantling procedure of the given battery.	**Unit-3.0 EV Power Transmission System** 3.1 **Transmission System**: Single and Multi-transmission system 3.2 **EV Power Train** 3.3 **EV Power Train Components**: Battery Pack, DC-AC Converter, Electric Motor, On-Board Charger. 3.4 **Battery Parameters**: Voltage, Current, Charging rate, efficiency, energy density, power density, State of Charge (SoC), Depth of Discharge (DoD), State of Health (SoH), Operating Temperature, specific energy, specific power, life cycle and cost. 3.5 Battery Assembly and Dismantling. 3.6 Gear and Differential Assembly 3.7 Safe disposal of used battery	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 3j. Describe the Mechanism of Gear and Differential Assembly.		
TSO 4a. Describe the Vehicle Control Unit (VCU). TSO 4b. Describe the functions of the given component of the Electronic Control Unit. TSO 4c. Describe the connections of the given control unit with the EV sub-system. TSO 4d. Explain the Interaction of Controller Area Network Communication with VCU. TSO 4e. Describe the Troubleshooting and Assessment procedure of VCU.	**Unit- 4.0 Vehicle Control Unit (VCU)** 4.1 **Electronic Control Unit**: Battery Management System, DC-DC Converter, Thermal Management System and Body Control Module. 4.2 Predefined functions 4.3 Connections with EV subsystem 4.4 Controller Area Network (CAN) communication 4.5 Interaction of CAN Communication with VCU. 4.6 Troubleshooting and Assessment 4.7 Dynamometers: Introduction 4.8 Environmental Chambers	**CO4**
TSO 5a. Explain the Classification of Charging Technologies. TSO 5b. Explain the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid. TSO 5c. Describe the testing procedure of the given Bi-directional charging systems. TSO 5d. Explain the Energy Management Strategies in the EV. TSO 5e. Explain the Wireless Power Transfer (WPT) technique for EV Charging.	**Unit- 5.0 EV Charging Technologies** 5.1 Charging Technology: Classification 5.2 Grid-to-Vehicle (G2V) 5.3 Vehicle to Grid (V2G) or Vehicle to Buildings (V2B) or Vehicle to Home(V2H). 5.4 Bi-directional EV Charging Systems. 5.5 Energy Management Strategies. 5.6 Wireless Power Transfer (WPT) technique for EV Charging.	**CO5**

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400604G

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 2.1 Test the operation of the Control Disc Braking system and control the regenerative braking system using a test rig. LSO 2.2 Test the performance (Speed v/s Braking Torque) of the Disc Braking System in Half step and Full step braking modes.	1.	• Testing of Control Disc Braking system and Control Regenerative Braking system.	**CO2**
LSO 2.3 Test the performance of different types of propulsion motors.	2.	• Testing of Motors	
LSO 2.4 Test the continuity of the automotive wiring system in the EV	3.	• Testing of the automotive wiring system.	
LSO 3.1 Test the performance of a new set of batteries and aged batteries. LSO 3.2 Compare the performance of the battery and find the Fuel Gauge after discharging the battery. a. 0% - 100% b. 30% - 100% c. 50% - 100% LSO 3.3 Evaluate the following parameters of the given EV battery. a. Specific power	4.	• Testing of Batteries used in EVs	**CO2, CO3**

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
b. Specific energy c. Life span and d. Cost parameters LSO 3.4 Evaluate the State of Health (SoH) of the given EV Battery after several charge/discharge cycles.			
LSO 3.5 Test the dynamic performance of the given motor; a) Speed and torque spectrum. b) Speed and torque oscillation c) Friction torque friction spectrum. LSO 3.6 Test the following speed-controlled performance characteristics of the given motor; a. Motor voltage over time b. Motor current over time. c. Speed and torque over time. d. Torque over speed. e. Current over speed. f. Electrical input power and the mechanical input power over speed	5.	Speed control of Electrical Motors	
LSO 4.1 Connect the components of the EC Units with EV subsystems. LSO 4.2 Troubleshoot basic faults in the electronic control unit of EV.	6.	• Connection of Electronic Control Unit components • Troubleshooting of electronic control unit	**CO4**
LSO 5.1 Evaluate the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid.	7.	Impacts of G2V and V2G	**CO 5**
LSO 5.2 Prepare a layout of a charging station	8.	Demonstration of Charging stations	

L) Suggested Term Work and Self-Learning: **S2400604G** Some sample suggested assignments, micro projects and other activities are mentioned here for reference.

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

b. Micro Projects:

1. Design and build a physical model of an EV motor and powertrain components from scratch.
2. Build and simulate communication systems of EVs using some software tools.
3. Prepare a report on "the way carbon credit works and companies utilize it to reduce their emission values".
4. Develop an EV prototype power train using locally procured hardware components.

c. Other Activities:

1. **Seminar Topics**:
   - Safe disposal process of Used Batteries.
   - Charging Technologies used for charging the EV.
   - EV power transmission systems.

2. **Surveys** – Visit an electric vehicle manufacturing plant and prepare report on HVAC system used in EV.

3. **Self-Learning Topics:**

- Impact of fleet charging of EVs on Power Systems.
- Energy Management in EV.
- Fuel Cell powered bus.
- EV Battery disposal and recycling.
- Mobility and connectors.

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

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self-Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	20%	15%	20%	--	--	--	--
CO-2	20%	20%	20%	--	--	35%	25%
CO-3	20%	30%	20%	70%	40%	40%	25%
CO-4	20%	25%	20%	30%	20%	10%	25%
CO-5	20%	10%	20%	--	40%	15%	25%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

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

Note:

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

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

Unit Title and Number	Total Classroom Instruction (Cl) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Vehicle Dynamics	8	CO1	12	4	5	3
Unit-2.0 Elements of Automobile.	10	CO2	15	5	6	4
Unit-3.0 EV Power Transmission System.	14	CO3	20	4	10	6
Unit-4.0 Vehicle Control Unit (VCU)	10	CO4	15	4	6	5
Unit-5.0 Charging Technologies	6	CO5	8	3	3	2
Total Marks	**48**		**70**	**20**	**30**	**20**

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA /ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1	Testing of Control Disc Braking system and Control Regenerative Braking system.	CO2	60	30	10
2	Testing of Motors.				
3.	Testing of automotive wiring system.				
4.	Testing of Batteries used in EVs	CO2, CO3	60	30	10
5.	Speed control of Electrical Motors		60	30	10
6.	Connection of Electronic Control Unit components	CO4	60	30	10
7.	Troubleshooting of electronic control unit				
8.	Impacts of G2V and V2G	CO 5	30	60	10
9.	Demonstration of Charging stations		70	20	10

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

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	Disc Braking and Regenerative braking system test rig	Test rig equipment for Demonstration of Disc Braking and Regenerative Braking system operation.	1
2.	Disc Braking System	Test rig / Software for testing the performance of the disc braking system in Half step and Full step braking mode.	1
3.	Induction motor	Induction motor For EV applications with testing kit	2,5
4.	Switched reluctance motor	Switched reluctance motor for EV applications with testing kit	2,5

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
5.	Permanent magnet (PM) DC motors	Permanent magnet (PM) DC motors for EV applications with testing kit	2,5
6.	Automotive wiring system	Testing facility of automotive wiring system using software /actual EV systems	3
7.	Lithium Ion and Lead-acid Batteries	12V, 7Ah with testing setup.	4
8.	Nickel-based batteries (metal hydride and cadmium battery).	12V, 7Ah with testing setup.	4
9.	Battery tester	For testing battery parameters	4
10.	Battery charger	Battery charger for EV	4
11.	Battery Management System	Training kit or simulation for BMS	4
12.	DC-DC Converter	48V to 12V bidirectional DC-DC Converter	4
13.	Power Analyser	To observe the impacts of G2V and V2G	5
14.	BMS setup	For Demonstration & training	4
15.	DC power supply	0-32V	5
16.	Charging Station Simulator	For Demonstration & training purposes.	5
17.	EC Unit with EV subsystems	Electronic Control Unit Hardware parts/ software for demonstrating the Connection of Electronic Control Unit components with EV subsystems.	6,7
18.	Facility to demonstrate the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid.	-	7

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Electric Vehicles: And the End of the ICE age	Anupam Singh	Kindle Edition ASIN: B07R3WFR28
2.	Wireless Power Transfer Technologies for Electric Vehicles (Key Technologies on New Energy Vehicles)	Xi Zhang, Chong Zhu, Haitao Song	Springer Verlag, Singapore; 1st ed. 2022 edition (23 January 2022) ISBN-13: 978-9811683473
3.	Modern Electric, Hybrid Electric, and Fuel Cell Vehicles	EHSANI	CRC Press; Third edition (1 January 2019) ISBN-13: 978-0367137465
4.	Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles	John G. Hayes, G. Abas Goodarzi	Wiley; 1st edition (26 January 2018) ISBN-13: 978-1119063643
5.	New Perspectives on Electric Vehicles	Marian Găiceanu (Editor)	IntechOpen (30 March 2022) ISBN-13: 978-1839696145
6.	Electric and Hybrid Vehicles,	Tom Denton, Taylor & Francis	2nd Edition (2020) ISBN- 9780429296109

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
7.	Hybrid Electric Vehicles: Energy Management Strategies	S. Onori, L. Serrao and G. Rizzoni	Springer (2016) ISBN: 978-1-4471-6781-5
8.	Electric & Hybrid Vehicles	A.K. Babu	Khanna Publishing House, New Delhi, 1st Edition (2018) ISBN: 9789386173713, 9386173719
9.	Power Electronics: Circuits, Devices and Applications,	Rashid, M. H.	Pearson, 3rd edition, (2013) ASIN: B07HB3BM1W

(b) Online Educational Resources:

2. https://www.energy.gov/eere/fuelcells/fuel-cell-systems
3. https://powermin.gov.in/en/content/electric-vehicle
4. https://www.iea.org/reports/electric-vehicles
5. https://www.oercommons.org/search?f.search=Electric+Vehicles
6. https://fame2.heavyindustries.gov.in/Index.aspx

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

(c) Others:

1. Learning Packages on EV
2. EV Users' Guide
3. EV Manufacturers' Manual
4. EV Lab Manuals

******

A) Course Code : **2400604H (T2400604H/P2400604H/S2400604H)**

B) Course Title : Robotics (Advance)

C) Pre- requisite Course(s) : Robotics (Basic)

D) Rationale :

Efficiency and quality are the demands of industry 4.0. Robotics is a constituent of Industry 4.0 which not only provides the former two but also is beneficial for hazardous and similar challenging situations. The use of robotic technology is developing at a very fast rate in all types of industries whether manufacturing, service or tertiary. Engineers should be competent to use the robotic technology for industry and society advantage. This course aims for the diploma engineers to have advanced skills in robotic applications and use in digital manufacturing.

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

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

CO-1 Plan the use of robots in engineering applications.

CO-2 Elucidate the conceptual place of the robotic components for engineering processes.

CO-3 Use robots for small automatic robotic applications.

CO-4 Compute the economics associated with use of robots in industries.

CO-5 Select appropriate robot for industrial requirements and other applications.

F) Suggested Course Articulation Matrix (CAM):

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

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

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

G) Teaching & Learning Scheme:

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				
2400604H	Robotics (Advanced)	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:

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)	
2400604H	Robotics (Advance)	30	70	20	30	20	30	200

Legend:

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

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

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: T2400604H

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Define the need and scope of industrial robots. *TSO 1b.* Describe the concept of robot dynamics with regards to methods for orientation and location of objects. *TSO 1c.* Analyse robot direct kinematics for the given 2 DOF planar manipulator. *TSO 1d.* List types of robots *TSO 1e.* List safety steps while handling the given robot.	**Unit-1.0 Robot Kinematics, Dynamics and Industrial Applications** 1.1 Definition need and scope of Industrial robots 1.2 Robot dynamics – Methods for orientation and location of objects 1.3 Planar Robot Kinematics – Direct and inverse kinematics for 2 Degrees of Freedom. 1.4 Safety while operating and handling robot	**CO2, CO3**
TSO 1f. Interface robots with the given welding machine. *TSO 1g.* Interface robots with the given painting machine. *TSO 1h.* Interface robots with the given assembly machine.	1.5 Robot Industrial applications: • Welding Robots-Welding Guns, Welding Electrodes, Welding Power Sources, shielding gases, Robot interfacing • Spray painting Robots, assembly operation, cleaning.	
TSO 2a. Explain the techniques to control robot motion. *TSO 2b.* Describe the given robot drive system. *TSO 2c.* Describe the types of grippers. *TSO 2d.* Design grippers for specific application. *TSO 2e.* Test the designed gripper for the application. *TSO 2f.* Use Bar code technology for robotic applications. *TSO 2g.* Integrate radio frequency identification technology in robotic applications. *TSO 2h.* Assemble an automated guided vehicle for the given situation using standard components. *TSO 2i.* Assemble a simple automated storage and retrieval systems (ASRS) for the given situation using standard components.	**Unit– 2.0 Robot Drives, Control and Material Handling** 2.1 Controlling the Robot motion. 2.2 Position and velocity sensing devices. 2.3 Drive systems – Hydraulic and Pneumatic drives 2.4 Linear and rotary actuators and control valves 2.5 Electro hydraulic servo valves, electric drives, motors 2.6 End effectors – Vacuum, magnetic and air operated grippers 2.7 Material Handling; automated guided vehicle systems, automated storage and retrieval systems (ASRS) 2.8 Bar code technology 2.9 Radio frequency identification technology.	**CO2, CO3**
TSO 3a. Differentiate between various work cell layouts. *TSO 3b.* Select work cell for specific robot with justification. *TSO 3c.* Analyse robot cycle time. *TSO 3d.* Explain industrial applications of robotic cell. *TSO 3e.* Follow safety procedures in robotic cell.	**Unit– 3.0 Robot Cell Design and Application** 3.1 Robot work cell design, control and safety 3.2 Robot cell layouts 3.3 Multiple Robots and machine interference 3.4 Robot cycle time analysis 3.5 Industrial application of robotic cells	**CO3**
TSO 4a. List different programming languages for the robots TSO 4b. Describe artificial intelligence	**Unit– 4.0 Robot Programming and Economics of Robotization**	**CO1, CO4, CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 4c. Write a programme in the required language to operate a robot for the given task. TSO 4d. Optimise robot programming parameters. TSO 4e. Select a robot on the basis of cycle time analysis. TSO 4f. Conduct an economic analysis for use of robots. TSO 4g. Follow testing methods and acceptance rules for industrial robots.	4.1 Characteristics of task level languages through programming methods 4.2 Motion interpolation 4.3 Artificial intelligence: Goals of artificial intelligence, AI techniques, problem representation in AI 4.4 Problem reduction and solution techniques. 4.5 Application of AI and KBES in Robots 4.6 Selection of Robots; Factors influencing the choice of a robot, selection of robot components, robot performance testing, work cycle time analysis 4.7 Economics analysis for robotics, cost data required for the analysis 4.8 Methods of economic analysis; Pay back method, equivalent uniform annual cost method, return on investment method. 4.9 Testing methods and acceptance rules for industrial robots	
TSO 5a. Describe applications of robots in healthcare and medicine. TSO 5b. Describe applications of robots in Construction industry. TSO 5c. Describe applications of robots in Underground coal mining. TSO 5d. Describe applications of robots in uutilities, military & firefighting operations. TSO 5e. Describe applications of robots in undersea and space TSO 5f. Describe applications of robots in brief in logistics, retail and hospitality, and smart cities. TSO 5g. Describe applications of robots in farming and agriculture in brief explain in brief the use of microrobots, nano robots, soft robots, humanoid robots	**Unit–5.0 Applications in Non-manufacturing Environments** 5.1 Applications of Robots in • Healthcare and medicine • Construction industry • Underground coal mines • Utilities, military & fire fighting operations • Undersea • Space • Logistics, • Retail and Hospitality • Smart Cities • Farming and Agriculture 5.2 Overview of Microrobots, nano robots, soft robots, humanoid robots	**CO5**

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400604H

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Identify Wireless Sensor Network. LSO 1.2 Use wireless sensor Network for different robotic applications	1.	Identify different wireless sensor network in robotics viz. ZigBee, LoRa.	CO1, CO3
LSO 2.1 Identify different Radio Frequency (RF) Controlled Wireless	2.	Use different Radio Frequency (RF) Controlled Wireless Robots.	CO1, CO2

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 2.2 Use Radio Frequency (RF) Controlled Wireless for different robotic applications.			
LSO 3.1 Identify the different Voice operated robot with speaker identification technology LSO 3.2 Use different Voice operated robot with speaker identification technology for different robotic applications.	3.	Examine different voice operated robot with speaker identification technology.	CO1, CO3
LSO 4.1 Identify the components required for a computer-controlled pick and place robot (wireless). LSO 4.2 Integrate the components for the required application.	4.	Design a computer-controlled pick and place robot (wireless)	CO1
LSO 5.1 Identify the components required for a Zigbee controlled Boat with wireless video and voice transmission. LSO 5.2 Integrate the components for the required application.	5.	Design a Zigbee controlled Boat with wireless video and voice transmission.	CO2, CO3
LSO 6.1 Identify the components required for a PC controlled wireless Multipurpose robot for engineering applications. LSO 6.2 Integrate the components for the required application.	6.	Design a PC controlled wireless Multipurpose robot for simple engineering applications.	CO2, CO4, CO5
LSO 7.1 Identify the components required for an unmanned arial photography LSO 7.2 Integrate the components for the required application.	7.	Design an unmanned arial photography system.	CO3, CO5
LSO 8.1 Develop a program LSO 8.2 Simulate palletizing and depalletizing operations through robots.	8.	Develop program for real time (online TPP) Palletizing and Depalletizing operations through robots.	CO5
LSO 9.1 Develop a program LSO 9.2 Simulate direction control and step control logic for robotization	9.	Develop TPP / Offline program for vision-based inspection for robots.	CO4, CO5
LSO 10.1 Develop a program LSO 10.2 Simulate robotising an inspection and part assembly.	10.	Program and simulate coordinated identification, inspection and part assembly for robots.	CO1, CO5
LSO 11.1 Develop a program. LSO 11.2 Simulate obstacle avoidance of robots.	11.	Develop obstacle avoidance robot Programming	CO1, CO5
LSO 12.1 PLC programming. LSO 12.2 Simulate robotising of welding operation.	12.	Program and simulate welding operation using robot simulation software.	CO1, CO5
LSO 13.1 Simulate robotising of drilling operation.	13.	TPP / Offline program for drilling operation.	CO1, CO5
LSO 14.1Develop a program for an industrial application. LSO 14.2Execute the robot programme.	14.	Program to execute an industrial robot application using a given configuration.	CO1, CO5
LSO 15.1 Use robot simulation software for Direct Kinematic analysis upto 4-axis robots LSO 15.2 Correlate the simulated results with respective mathematical calculations.	15.	Analyse Direct Kinematics of 4-axis robot using available software.	CO2

L) Suggested Term Work and Self Learning: S2400604H Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

b. **Micro Projects:** A suggestive list of micro-projects is given here. Similar micro-projects that match the COs could be added by the concerned course teacher. The student should strive to identify eco-friendly or recycled material prior to selection for robotic applications.

- Develop coin separating robot.
- Develop robot using radio frequency sensors for material handling.
- Develop robot for land mine detection.
- Develop a robot for car washing.

c. Other Activities:

1. Seminar Topics: Recent developments in the industrial applications of robotics
2. Visits: Visit a robotic exhibition.
3. Case Study: Identify a robotic application in automobiles and present a case study
4. Download videos related to simple robotic applications in domestic and industrial purposes.
5. Self-Learning Topics:
   - Robotic component manufacturers

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

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self- Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	25%	23%	20%	10%	25%	10%	20%
CO-2	20 %	23%	20%	10%	25%	20%	20%
CO-3	15%	17%	20%	25%	25%	20%	20%
CO-4	20%	20%	20%	15%	25%	20%	20%
CO-5	20%	17%	20%	40%	--	30%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

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

****:** Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

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

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

Unit Number and Title	Total Classroom Instruction (Cl) Hours	Relevant COs Number (s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Robot Kinematics, Dynamics and Industrial Applications	12	CO2, CO3	16	6	5	5
Unit– 2.0 Robot Drives, Control and Material Handling	10	CO2, CO3	16	4	8	4
Unit– 3.0 Robot Cell Design and Application	8	CO3	12	2	4	6
Unit– 4.0 Robot Programming and Economics of Robotization	10	CO1, CO4, CO5	14	4	4	6
Unit– 5.0 Applications in Non-manufacturing Environments	8	CO5	12	4	4	4
Total Marks	**48**		**70**	**20**	**25**	**25**

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

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Identify different wireless sensor network in robotics viz. ZigBee, LoRa.	CO1, CO3	40	50	10
2.	Use different Radio Frequency (RF) Controlled Wireless Robots.	CO1, CO2	40	50	10
3.	Examine different voice operated robot with speaker identification technology.	CO1, CO3	40	50	10
4.	Design a computer-controlled pick and place robot (wireless)	CO1, CO4	40	50	10
5.	Design a Zigbee controlled Boat with wireless video and voice transmission.	CO2, CO3	40	50	10
6.	Design a PC controlled wireless Multipurpose robot for simple engineering applications.	CO3, CO4	40	50	10
7.	Design an unmanned arial photography system.	CO3, CO5	40	50	10
8.	Develop program for real time (online TPP) Palletizing and Depalletizing operations through robots.	CO5	40	50	10
9.	Develop TPP / Offline program for vision-based inspection for robots.	CO4, CO5	40	50	10
10.	Program and simulate coordinated identification, inspection and part assembly for robots.	CO1, CO5	40	50	10

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
11.	Develop Obstacle avoidance robot Programming	CO1, CO5	40	50	10
12.	Program and simulate welding operation using robot simulation software.	CO1, CO5	40	50	10
13.	TPP / Offline program for drilling operation.	CO1, CO5	40	50	10
14.	Program to execute an industrial robot application using a given configuration.	CO1, CO5	40	50	10
15.	Analyse Direct Kinematics of 4-axis robot using available software.	CO2, CO3	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, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources(OER), MOOCs etc.

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/ Practical Number

1.	6 Axis Articulated Robot (Material Handling)- 1 No	• Articulated Type
		• Controlled axis: 6-axes (J1, J2, J3, J4, J5, J6)
		• Reach: 717 mm
		• Installation Floor, Upside-down (Angle mount)
		• Motion range (Maximum Speed)
		  • J1 Axis Rotation7.85 rad/s
		  • J2 Axis Rotation 6.63 rad/s
		  • J3 Axis Rotation 9.08 rad/s
		  • J4 Axis Rotation 9.60 rad/s
		  • J5 Axis Rotation 9.51 rad/s
		  • J6 Axis Rotation 17.45ras/s
		• Max. load capacity Wrist: 4Kg
		• Allowable Load moment 16.6 N-m at wrist J4 Axis, J5 Axis, J6 Axis
		• Allowable Load inertia).47 kg-m^2 at wrist J4 Axis J5 Axis, J6 Axis
		• Repeatability: +/- 0.05mm
		• Mass: 21 Kg Minimum
		• Installation environment: Ambient temperature: 0 – 45°C
		• Ambient humidity: Normally 75%RH or less. No dew, nor frost allowed.
			1, 2, 3, 12

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/ Practical Number
		• Vibration Acceleration: 4.9 m/s2 (0.5G or less)	
2.	6 Axis Articulated Robot (General Purpose-Welding, Assembly, Drilling) - 1 No	Link 1: 300 mm Link 2: 300 mm Joint actuator: DC Stepper Motor Transmission: Timing Belt Drive Position feedback: Proximity Switch Gripper actuator: Pneumatic Weight of robot: 50 Kg. Accuracy: ±0.3 Repeatability: ±0.2Tip Velocity range: 500 mm / minPay load capacity: 2 kg (including griper) J1 - Waist: ± 140°J2 - Shoulder: -100 - 60°J3 - Elbow: - 70 + 10°J4 - Wrist rotate: ± 70°J5 - Wrist pitch: ± 35°J6 - Wrist roll: ± 180°External I/O8 Programmable digital inputs8 Programmable digital outputs	8, 9, 14
3.	A mounted vision system with software (Free open source Robot simulation software)	Integrity Serial Bus System, CAN to Build Intelligent Device Network, Open Hardware Platform, Arduino, to control Robot sub-Systems of motor-sensor, movable Omni Wheel of Omni-Directional, Actuator operation control by DC Encoder Motor, DC-Motor control and operation by Accelerometer, Gyro, Ultrasonic and PSD sensor, Androx Studio; brushless ILM 70×10 Robo Drive DC motor; sensor-actuator units of ARMAR-4; SD-25-160-2A-GR-BB Harmonic Drive reduction gear unit high gear ratio of 160: 1; structural parts (white) are made out of high-strength aluminum, Hollow shaft with strain gauges for torque sensing, motor's magnetic incremental encoder (AMS5306), digital buses (SPI or 12C); Motor interface PCB includes a 13-Bit temperature-to-digital converter with a temperature range from −40°C to 125°C (Analog Devices ADT7302)	3, 4, 5, 11
4.	6-axis Robotics Trainer	Programmable robotic arm with an interactive front panel. Software to demonstrates functioning of the trainer as well as allows a user to develop their own programs. NV330; 8 bit microcontroller to ARM processors**;** Record and Play capability**;** Optional interfacing with PL**C;** Touch operated ON/OFF Switch**;** Auto set to home position**;** Applications can be developed**;** Data acquisition using USB	3, 4, 5, 13
5.	E-Yantra Firebird kit	• Fire Bird V 2560 Robot • Spark V Robot • Fire Bird V P89V51RD2 adapter card • Fire Bird V LPC2148 adapter card • LSM303 3 axis digital accelerometer and 3 axes magnetometers • L3G4200 3 axis digital gyroscope • Gyroscope, accelerometer and GPS interfacing module for the robot • GPS receiver • Zigbee Modules 100m range • Zigbee Modules Adapter • Metal-gear Servo Motors • Servo Motor Based Gripper kit for the Fire Bird V robot • Sharp infrared range sensor (10cm to 500cm) • Arduino Uno/Nano	1, 3, 5, 6, 7, 10

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/ Practical Number
		• Hexapod • 16 Programming Software (AVR studio, Keil, AVR Boot loader, Flash Magic)	
6.	Robot simulator for Robotics	Educational networking licensed Robotic system with simulation software	2, 8, 10
7.	Assorted sensors	Optical encoders, Acoustic sensors ,IR, Potentiometer, RTD, Thermistor, strain gauge, piezoelectric, etc.	4
8.	Vision equipment	Camera, Imaging Components: Point, Line, Planar and Volume Sensors	1, 4, 10
9.	Raspberry Pi kit	1.2GHz quad-core Broadcom BCM2837 CPU with 1GB DDR2 RAM with in-built Wi-Fi & Bluetooth Video Core IV 3D graphics core 40 pin extended pins - with 27 GPIO pins Micro SD slot Multiple ports: Four USB ports, full sized HDMI, four pole stereo output and composite video port, CSI camera port and DSI display port 10/100 BaseT Ethernet Micro-USB, power source 5V, 2A	7, 9

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Introduction to Robotics Mechanics and Control	John Craig	Pearson Education 978-9356062191
2.	Robotics and controls	Mittal R.K., Nagrath I.J.	Tata McGraw Hill Education Pvt. Ltd.; 2017; **978**-0070482937
3.	Robotics and Image Processing: An Introduction	Janaki Raman. P. A	Tata McGraw Hill Publishing company Ltd., 1998; 978-0074621677
4.	Industrial Robotics -Technology, Programming and Applications	Nicholas Odrey, Mitchell Weiss, Mikell Groover Roger Nagel, Ashish Dutta	McGraw Hill Education; 2nd Edition; 978 -1259006210
5.	Robotic Engineering: an integrated approach	Richard D. Klafter, Thomas A. Thomas A. Chmielewski, Michael Negin	Prentice Hall of India, N. Delhi, 2009; 978-8120308428
6.	Industrial Robotics Technology, Programming and Applications	Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey	McGraw-Hill Education, Second Edition, 978-1259006210
7.	Robotics	Appuu Kuttan K. K.	Dreamtech Press, First Edition, 2020, 978-9389583281
8.	Introduction to Robotics: Analysis, Control, Applications	Saeed B. Niku	Wiley; Second Edition, 978-8126533121
9.	Essentials of Robotics Process Automation	S. Mukherjee	Khanna Publication, First Edition, 978-9386173751
10.	Robotics	R R Ghorpade, M M Bhoomkar	Nirali Prakashan 978-9388897020

(b) Online Educational Resources:

1. https://web.iitd.ac.in/~saha/ethiopia/appln.pdf
2. https://nptel.ac.in/courses/112105249
3. https://www.robotsscience.com/industrial/industrial-robots-types-applications-benefits-and-future/
4. https://www.marian.ac.in/public/images/uploads/pdf/online-class/MODULE-6%20ROBOTICS%20INDL_APPLNS-converted.pdf
5. https://forcedesign.biz/blog/5-common-industrial-robot-applications
6. https://www.hitechnectar.com/blogs/top-industrial-robotics-applications-role-of-robots-in-manufacturing/
7. https://en.wikipedia.org/wiki/Industrial_robot
8. https://www.youtube.com/watch?v=fH4VwTgfyrQ
9. https://www.youtube.com/watch?v=aW_BM_S0z4k
10. https://www.automate.org/industry-insights/smarter-robot-grasping-with-sensors-software-the-cloud
11. https://robots.ieee.org/robots/?t=all
12. https://www.youtube.com/watch?v=fc_Cynqr6jM

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

(c) Others:

1. Learning Packages:

- https://www.edx.org/learn/robotics
- https://www.coursera.org/courses?query=robotics
- https://www.udemy.com/topic/robotics/
- https://library.e.abb.com/public/9a0dacfdec8aa03dc12578ca003bfd2a/Learn%20with%20ABB.%20Robotic%20package%20for%20education.pdf

2. Users' Guide:

- https://roboindia.com/store/DIY-do-it-your-self-educational-kits-robotics-embedded-system-electronics
- https://www.robomart.com/diy-robotic-kits
- https://www.scientechworld.com/robotics

3. Lab Manuals:

- http://www-cvr.ai.uiuc.edu/Teaching/ece470/docs/ROS_LabManual.pdf
- https://www.jnec.org/labmanuals/mech/be/sem1/Final%20Year%20B.Tech-ROBOTICS%20LAB%20%20MANUAL.pdf

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A) Course Code : **2400604I(T2400604I/P2400604I/S2400604I)**

B) Course Title : Transformer Manufacturing and Repairing (Advanced)

C) Pre- requisite Course(s) : Transformer Manufacturing and Repairing (Basic)

D) Rationale :

Transformers are an essential component in Power systems. They help transmit electrical energy at various voltage and current levels to minimize losses and achieve other technical objectives. They are rated from a few kVA to large MVA. Power systems are growing to meet the increased demand. Hence, the manufacturing of new transformers and repair of existing transformers are vital. This advanced course will help the students understand the concepts of manufacturing and repair of transformers at par with the industries. The knowledge gained through this course will help the students choose their career in transformer manufacturing and repair.

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 materials used in transformer manufacturing.
CO-2 Assemble the transformer based on specific requirements.
CO-3 Design using software based on specific requirements.
CO-4 Analyze the working conditions of transformers.
CO-5 Apply the concepts for practical use.

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	-	3		
CO-2	3	3	2	2	2	-	3		
CO-3	3	2	2	2	-	-	3		
CO-4	3	1	1	1	1	-	3		
CO-5	3	2	3	3	3	1	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:

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				
2400604	Transformer Manufacturing and Repairing (Advanced)	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:

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)	
2400604	Transformer Manufacturing and Repairing (Advanced)	30	70	20	30	20	30	200

Legend:

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

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

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

Note:

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

I) Course Curriculum Detailing:

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

J) Theory Session Outcomes (TSOs) and Units: T2400604I

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain the use of different materials in transformers. *TSO 1b.* List the various types of materials used in transformers. *TSO 1c.* Explain the insulating materials. *TSO 1d.* Explain the winding material. *TSO 1e.* Explain the magnetic materials.	**Unit-1.0 Transformer Materials** 1.1 Review of basic materials and their processing 1.2 Insulating oil, insulating paper, pressboard, wood 1.3 Insulated copper conductor for windings, crepe paper, sealing materials 1.4 cold–rolled grain oriented electrical steel sheet, structural steel, future trends 1.5 Magnetic Circuit Materials	**CO1**
TSO 2a. Explain the basic concept of transformer design. *TSO 2b.* List the various parameters to be considered during design. *TSO 2c.* Choose the number of turns, the core diameter. *TSO 2d.* Select the winding wires and strips. *TSO 2e.* Choose the size of HV and LV conductors.	**Unit-2.0 Transformer Design** 2.1 Basic Concept of Design. 2.2 Selection of number of turns. 2.3 Selection of core diameter. 2.4 Selection of winding wires and strips. 2.5 Size HV and LV conductors. 2.6 Transposition	**CO1, CO2**
TSO 3a. Explain the concept of computer aided design. *TSO 3b.* Learn the programming skills, *TSO 3c.* Modify the programming considering other aspects. *TSO 3d.* Validate and print the design. *TSO 3e.* Use software to design.	**Unit-3.0 Transformer Design – Using CAD** 3.1 Computer aided design: Basic concept, specification needs. 3.2 Computer programming, variable inputs, program convergence. 3.3 Design output, design modification, other aspects of design. 3.4 Design validation, design package, computer design printout. 3.5 Software application for design.	**CO3, CO4**
TSO 4a. Explain the testing of Transformer oil. *TSO 4b.* Use of Transformer oil. *TSO 4c.* List the causes of oil ageing. *TSO 4d.* List the various tests to monitor the working conditions of a transformer.	**Unit-4.0 Transformer Condition Monitoring** 4.1 Transformer oil testing and Interpretation 4.2 Introduction, mineral insulating oil. 4.3 Four functions of transformer oil. 4.4 Causes of oil ageing. 4.5 Various tests on transformer oil such as power factor, moisture, neutralization number, interfacial tension, relative density, color, visual examination, breakdown voltage, dissolved gas analysis.	**CO3, CO4**
TSO 5a. Apply the concepts for practical use. *TSO 5b.* Design a practical power transformer.	**Unit-5.0 Transformer Design - Practical Applications** 5.1 Design of a 100 KVA transformer. 5.2 Design of 630 KVA transformer. 5.3 Design of 5 MVA, 33/11 KV transformer	**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: P2400604I

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1. Knowledge of knowing the various components of a power transformer. *LSO 1.2.* Explain the use of those components in the power transformer.	1.	Dismantling a power transformer and understanding various components.	**CO1**
LSO 2.1. Design a transformer using computer programming considering various aspects.	2.	Designing a transformer using computer programming.	**CO1**
LSO 3.1. Use of a commercial software to design a transformer.	3.	Application of software for transformer design.	**CO1**
LSO 4.1. Understand the breakdown voltage (BDV) of transformer oil.	4.	Breakdown voltage test of transformer oil.	**CO2**
LSO 5.1. Explain the practical applications of power transformers. *LSO 5.2.* Knowledge of various transformers used in substations.	5.	Substation visit to see the application of power transformers.	**CO3, CO4, CO5**

L) Suggested Term Work and Self Learning: S2400604I 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.

- Explore recent advancements in core material technology.
- Discuss the lifecycle, recycling, and disposal of transformer materials and their environmental footprint.
- Discuss the key parameters and design equations used in transformer design.
- Explore the steps involved in modeling the transformer core using CAD software.
- Use CAD software to simulate different winding configurations and their impact on performance.
- Discuss the advantages of real-time data collection and analysis for proactive maintenance.
- Investigate the different requirements for distribution transformers in urban versus rural settings.

b. Micro Projects:

- Compare the performance of different insulating materials used in transformers (e.g., paper, pressboard, Nomex).
- Study the magnetic properties of different core materials (e.g., silicon steel, amorphous steel).
- Evaluate the environmental impact of transformer materials and their disposal methods.
- Build a small-scale transformer to understand the basics of transformer construction and operation.
- Investigate the impact of different winding techniques on transformer efficiency and performance.
- Compare different core materials to determine their effect on transformer performance.
- Design various core shapes (e.g., E-core, toroidal, C-core) using CAD and analyze their magnetic properties.
- Design and optimize different winding layouts to improve efficiency and reduce losses.
- Design a system to monitor and log the temperature of transformer components.
- Monitor transformer vibrations to detect mechanical issues.
- Design a system to monitor the quality of transformer oil.
- Develop a lightweight, portable transformer for powering equipment at outdoor events.

c. Other Activities:

1. Seminar Topics:
   - Silicon Steel in Transformer Manufacturing.
   - Impact of Environmental Factors on Transformer Design.
   - Introduction to CAD in Transformer Design.
   - Cost Estimation and Analysis in Transformer Design Using CAD.
   - Impact of Environmental Conditions on Transformer Monitoring.
   - Oil Quality Analysis in Transformer Maintenance.
   - Designing Transformers for Industrial Applications.

2. Visits:
   - Visit to nearby transformer manufacturing station. Prepare report of visit with special comments on transformer winding technique, winding material and insulating material used.
   - Visit to nearby transformer manufacturing station. Prepare report of visit with manufacturing process, different stages of production, and the quality control measures and technologies involved in transformer manufacturing.

3. Self-learning topics:
   - Types of insulation materials used in transformers (e.g., paper, pressboard, synthetic materials, and mineral oil)
   - Nanomaterials in Transformer Construction.
   - Thermal management in transformer design.
   - Vibration of transformer.
   - Smart transformer used in smart grid.

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%**	-	-	**20%**	20%
CO-2	10%	10%	10%	25%	-	**10%**	20%
CO-3	15%	15%	15%	25%	33%	**15%**	20%
CO-4	30%	30%	30%	25%	33%	**15%**	20%
CO-5	30%	30%	30%	25%	34%	**40%**	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

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

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- 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 **Transformer Materials**	8	CO1	10	3	3	4
Unit-2.0 **Transformer Design**	12	CO1, CO2	10	3	2	5
Unit-3.0 **Transformer Design-Using CAD**	12	CO3, CO4	10	5	2	3
Unit-4.0 **Transformer Condition Monitoring**	8	CO3, CO4	20	5	6	9
Unit-5.0 **Transformer Design - Practical Applications**	8	CO4, CO5	20	4	6	10
Total	**48**	**-**	**70**	**20**	**19**	**31**

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

O) Suggested Assessment Table for Laboratory (Practical):

SN	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Dismantling a power transformer and understanding various components.	CO1	30	60	10
2.	Designing a transformer using computer programming.	CO1	40	50	10
3.	Application of software for transformer design.	CO1	30	60	10
4.	Breakdown voltage test of transformer oil.	CO2	30	60	10
5.	Substation visit to see the application of power transformers.	CO3, CO4, CO5	30	60	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.	Transformer, Multi-meter, LCR Meter	3 Phase Transformer, Multi-meter, LCR Meter, Tools to dismantle transformer.	Dismantling a power transformer and understanding various components.
2.	MATLAB, PC	MATLAB Software and Desktop PC (As per requirement).	Designing a transformer using computer programming
3.		Machine Design Software and Desktop PC (As per requirement).	Application of software for transformer design.
4.	Transformer Oil Testing Kit	Transformer oil testing kit, transformer oil,	Breakdown voltage test of transformer oil.
5.	Equipment for a prototype substation	Power transformer, circuit breaker, relay, Insulator, Isolator, Bus-bar, capacitor bank, Fuse, current transformer, potential transformer.	Substation visit to see the application of power transformers

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Transformer Engineering Design and Practice	S.V.Kulkarni, S.A.Khaparde	CBS Publishers, 2004 ISBN: 9780824757281, 0824757289
2.	Design of Transformers	Indrajit Dasgupta	Tata McGraw Hill India, 2002 ISBN: 0071331352, 9780071331357
3	Principles of Electrical Machine Design With Computer Programs	S. K. Sen	Oxford & IBH Publishing Company Pvt. Limited, 2006. ISBN: 9788120415218, 8120415213

(b) Online Educational Resources:

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:

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A) Course Code : 2400604J(T2400604J/P2400604J/S2400604J)

B) Course Title : Optical Fiber and 5G Communication (Advance)

C) Pre- requisite Course(s) : Optical Fiber and 5G Communication (Basics)

D) Rationale :

A course on Optical Fiber and 5G Communication (Advance) is essential to understand the modern high-speed data transmission, which is crucial for supporting the growing demand for fast and reliable internet services. It equips students with the knowledge to design and implement 5G networks, which is going to be an integral part of the wireless communication infrastructures fields, students gain comprehensive insights into how advanced communication systems operate and interact, preparing them for careers in telecommunications and networking.

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-6 Analyze various 5G radio-access technologies.

CO-7 Identify different components of GSM architecture.

CO-8 Describe the channel and channel behavior of the wireless channel.

CO-9 Analyze different mitigation techniques.

CO-10 Summarize different emerging technologies for next generation communication networks.

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	3	-	-	2		
CO-2	3	2	2	2	2	2	-		
CO-3	3	2	2	2	3	2	-		
CO-4	3	3	-	2	-	-	-		
CO-5	3	-	3	3	3	3	2		

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

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

G) Teaching & Learning Scheme:

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				
2400604J	**Optical Fiber and 5G Communication (Advance)**	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:

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)	
2400604J	Optical Fiber and 5G Communication (Advance)	30	70	20	30	20	30	200

Legend:

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

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

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

Note:

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

II) 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: T2400604J

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1f. Highlight the need for 5G communication system. *TSO 1g.* Describe the radio spectrum andchannel model with the help of suitable sketch and tables. *TSO 1h.* Describe the working of the 5G physical layer with the help of a suitable sketch. ~~*TSO 1i.*~~ Describe 5G network slicing with an example. *TSO 1j.* Explain the mobility and hands-off management in 5G environment.	**Unit-1.0 5G Radio Access Technology** 1.6 5G Radio Spectrum 1.7 5G Channel Model 1.8 Radio Interface Architecture 1.9 5G Physical Layer 1.10 5G Radio-Access Technologies 1.11 Introduction To 5G Network Slicing 1.12 Mobility and Handoff Management In 5G	**CO1**
TSO 2f. Describe the architecture and key components of basic GSM (Global System for Mobile Communications) networks. *TSO 2g.* List the components of the GSM(LTE) system. *TSO 2h.* Describe the working of the various components and their functions of the given type of wireless communication network *TSO 2i.* Analyze the functions of base station subsystems (BS)	**Unit-2.0 Study of GSM Architecture** 2.7 GSM System Architecture (LTE) 2.8 Explain the different components of Wireless Communication Network 2.9 Operation of base station (BS) subsystems	**CO2**
TSO 3f. Explain different principles and various factors affecting radio wave propagation in different environments. *TSO 3g.* Apply the free space propagation model to estimate signal strength and coverage. *TSO 3h.* Explain how reflection, scattering, and diffraction impact radio wave behaviour and signal quality. *TSO 3i.* Use the given type of path loss models to predict signal degradation over distance. *TSO 3j.* Differentiate between large-scale and small-scale fading and their effects on wireless communication. *TSO 3k.* Analyze the characteristics and behaviour of wireless channels, including their impact on signal transmission. *TSO 3l.* List the noise sources present in the wireless channel. *TSO 3m.* Describe the effects of noise on signal propagation through wireless channels and its impact on signal quality. *TSO 3n.* Calculate the capacity of channels with Additive White Gaussian Noise (AWGN).	**Unit-3.0 Channel and channel behavior** 3.6 Analysis of radio wave propagation 3.7 Free Space Propagation Model 3.8 Reflection, Scattering, Diffraction of Radio Waves 3.9 Path Loss Models 3.10 Study of Fading (Large, small-scale fading) 3.11 Analysis of Wireless Channel 3.12 Analysis of Noise, types of noise 3.13 Capacity of AWGN and Fading Channel (only formula and its variable parameters)	**CO3**
TSO 4e. Describe various diversity techniques to improve signal reliability and performance in wireless communication. *TSO 4f.* Describe receiver diversity methods and their impact on enhancing signal quality and reducing errors. *TSO 4g.* Describe transmitter diversity techniques and their role in mitigating fading and improving communication robustness. *TSO 4h.* Describe the principles and applications of Multiple Input Multiple Output (MIMO) technology. *TSO 4i.* Suggest the techniques to correct distortions and mitigate inter-symbol interference in wireless communication systems.	**Unit-4.0 Mitigation Techniques** 4.6 Diversity techniques 4.7 Analysis of various receiver diversity techniques 4.8 Analysis of various transmitter diversity techniques 4.9 MIMO technology advantages in communication systems 4.10 Equalization techniques and their importance in communication systems	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 5c. Discuss the various types of dispersion in optical fibre design *TSO 5d.* Explain the optimization technique of single mode fibre. *TSO 5e.* Describe the working and characteristics of different optical networks. *TSO 5f.* Explain the nonlinear effect on network performance of optical fibre systems. *TSO 5g.* Explain multicarrier modulation techniques to enhance data transmission and system performance. *TSO 5h.* Describe the principles and advantages of Orthogonal Frequency Division Multiplexing (OFDM) in improving bandwidth efficiency and reducing interference. *TSO 5i.* Analyze given emerging technologies.	**Unit-5.0 Advanced Optical Fiber Communication and Emerging Technologies** 5.4 Advanced Optical Fiber: Dispersion issues, Dispersion shifted, Dispersion flattened, Dispersion Compensating fibre 5.5 Design and optimization of single-mode fibers 5.6 Optical Networks- Basic Networks SONET, SDH-wavelength-routed networks 5.7 Nonlinear effect on Network Performance, performance of various systems (WDM, DWDM + SOA) 5.8 Multicarrier Modulation Technique 5.9 Orthogonal Frequency Division Multiplexing (OFDM) 5.10 Emerging Technology: Green Communication network, Vehicle 2 everything (V2X), Aerial Communication, Satellite Communication (LEO), Tactile Internet (TI), Free Space Optics (FSO), Near Field Communication, Quantum Communication, Molecular Communication	**CO5**

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

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400604J

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.3. Noise Modelling and its effect on Wireless Data Transmission	1.	Characterization and Impact of Noise on Wireless Data Transmission: A Comprehensive	**CO1**
LSO 2.2. Effect of fading on wireless data transmission in terms of outage probability	2.	Evaluating Fading Effects on Wireless Data Transmission: Outage Probability Analysis	**CO2**
LSO 3.2. Capacity of Wireless Channel (AWGN v/s Fading)	3.	Comparative Study of Channel Capacity: AWGN versus Fading Channels	**CO3**
LSO 4.2. Implementation of receiver diversity technique.	4.	Practical Implementation and Evaluation of Receiver Diversity Techniques in Wireless Communication	**CO4**
LSO 5.3. Implementation of transmitter diversity technique.	5.	Practical Implementation and Performance Analysis of Transmitter Diversity Techniques	**CO4**
LSO 6.1 Implement the (2X2) of MIMO system.	6.	Design and Implementation of MIMO Technology	**CO4**
LSO 7.1 Implement of OFDM system and test the performance.	7.	Performance Evaluation of Orthogonal Frequency Division Multiplexing (OFDM) in Wireless Systems	**CO5**

L) Suggested Term Work and Self Learning: S2400604J Some sample suggested assignments, micro project and other activities are mentioned here for reference.

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

e. Micro Projects:

Here are five micro projects that can be included in an optical fiber and 5G communication course to give students hands-on experience with practical applications of the concepts learned:

1. Design of solar cell enabled Base Station for Green Communication Network

Task: Conduct a feasibility study on integrating solar cells with base stations, design a prototype solar-powered base station, simulate its energy efficiency and environmental impact, evaluate its carbon footprint reduction, and document the design and performance outcomes.

2. Path loss models for Aerial Communication Network

Task: Research and adapt existing path loss models for aerial networks, develop tailored models for scenarios like drones, validate with field or simulation data, compare model performance, and document findings with recommendations for network design.

3. Resource allocation for 5G communication Network

Task: Identify challenges in 5G resource allocation, develop an optimization strategy, simulate the strategy's effectiveness, implement it in a test environment, and analyze results to enhance resource allocation and network performance.

4. LEO Satellite based IoT communication

Task: Research LEO satellite technologies for IoT, design a communication system using LEO satellites, simulate system performance, conduct a cost-benefit analysis compared to other methods and prepare a brief report of the same.

5. QoS requirements for Tactile Internet

Task: Define QoS requirements for tactile internet applications, develop a QoS framework, test the framework in various scenarios, evaluate its performance, and prepare a report with recommendations for meeting QoS standards in tactile internet networks.

f. Other Activities:

g. Seminar Topics: Some of the suggested seminar topics are

i. "Advancements in 5G Technology and beyond"
ii. "The Future of Wireless Communication: 5G and Beyond"
iii. "Integrating Haptics with 5G Networks: Opportunities and Challenges"
iv. "Security Strategies for 5G Networks: Ensuring Robust Protection"
v. "AR/VR-enabled Systems in 5G: Innovations and Implementation"

h. Visits: Visit nearby telephone exchanges or wireless communication-related companies

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%	-	-	20%	20%
CO-2	10%	10%	10%	25%	-	10%	20%
CO-3	15%	15%	15%	25%	33%	15%	20%
CO-4	30%	30%	30%	25%	33%	15%	20%
CO-5	30%	30%	30%	25%	34%	40%	20%
Total Marks	30	70	20	20	10	20	30
			50				

Legend:

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

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- 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 **5G Radio Access Technology**	8	CO1	12	4	4	4
Unit-2.0 **Study of GSM Architecture**	8	CO2	12	4	4	4
Unit-3.0 **Channel and channel behavior**	8	CO3	12	4	4	4
Unit-4.0 **Mitigation Techniques**	12	CO3	14	4	4	6
Unit-5.0 **Advanced Optical Fiber Communication and Emerging Technologies**	12	CO2	20	6	6	8
Total	**48**	**-**	**70**	**22**	**22**	**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): Kindly change this table as per the list of experiment in the above list

Sl. No	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
6.	Characterization and Impact of Noise on Wireless Data Transmission: A Comprehensive	**CO1**	30	60	10
7.	Evaluating Fading Effects on Wireless Data Transmission: Outage Probability Analysis	**CO2**	40	50	10
8.	Comparative Study of Channel Capacity: AWGN versus Fading Channels	**CO3**	30	60	10
9.	Practical Implementation and Evaluation of Receiver Diversity Techniques in Wireless Communication	**CO4**	30	60	10
10.	Practical Implementation and Performance Analysis of Transmitter Diversity Techniques	**CO4**	30	60	10
11.	Design and Implementation of MIMO Technology	**CO4**	30	60	10
12.	Development and Performance Evaluation of Orthogonal Frequency Division Multiplexing (OFDM) in Wireless Systems	**CO5**	30	60	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:

Please insert laboratory equipment in this format

Sl. No.	Name of Equipment,Tools, and Software	Relevant Experiment/ Practical Number
1.	Software-Defined Radio (SDR) kit : Allows for the implementation and testing of 5G communication protocols.	All
2.	5G NR Testbed: Complete test setups for developing and testing 5G NR systems.	All
3.	Vector Signal Analyzer (VSA) and Vector Signal Generator (VSG): For generating and analyzing complex modulated signals used in 5G communication.	All
4.	MIMO (Multiple Input Multiple Output) Test System (2X2, and more): For testing MIMO technology, which is essential for 5G networks.	All
5.	MATLAB/Mathematica	All

R) Suggested Learning Resources:

(a) Books

Here are some essential books for Optical Fiber and 5G Communication.

Sl. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Millimeter Wave Wireless Communications	Theodore S. Rappaport, Robert W. Heath Jr., Robert C. Daniels, and James N. Murdock	Cambridge University Press, 2024. ISBN 9781009489836
2.	5G NR: The Next Generation Wireless Access Technology	Erik Dahlman, Stefan Parkvall, and Johan Skold	Academic Press, 2020. ISBN-10. 0128143231; ISBN-13. 978-0128143230
3.	Wireless Communications	Andreas F. Molisch,	John Wiley & Sons, 2012. ISBN: 8126542322
4.	Wireless Communications	Andrea Goldsmith	Cambridge University Press, 2005. ISBN: 9780511841224

(b) Online Educational Resources:

Here are some valuable online references for a course in Optical Fiber and 5G Communication:

1. Prof. Aditya K. Jagannatham– NPTEL **Principles of Modern CDMA/ MIMO/ OFDM Wireless Communications**
2. **Coursera** - Post Graduate Certificate in 5G Technology and IoT: This program covers the essentials of 4G and 5G systems, including key technical advancements and challenges. It also delves into topics such as massive MIMO, OFDM, and mm Wave communication, providing a solid foundation in modern wireless communication (Coursera).
3. **Coursera** - 5G and Beyond Wireless Technologies: This course provides an in-depth understanding of 5G New Radio standards, beam management, cell-free massive MIMO, and intelligent reflecting surfaces, making it an excellent resource for those looking to explore the cutting-edge aspects of 5G technology (Coursera).
4. **Coursera** - 5G for Everyone: Gain an in-depth understanding of how 5G is revolutionizing the way we do business in the 2020s with technologies that make 5G possible, including mm Wave, Massive MIMO, RAN, and more. Learn how companies can use 5G Private Networks and Industrial IoT to transform the way they operate daily. Gain the base-level knowledge of 5G you need to continue your wireless education and advance in the rapidly growing field of wireless technology.

MIT OCW - Principles of Wireless Communications: This course is an introduction to the design, analysis, and fundamental limits of wireless transmission systems. Topics to be covered include: wireless channel and system models; fading and diversity; resource management and power control; multiple-antenna and MIMO systems; space-time codes and decoding algorithms; multiple-access techniques and multiuser detection; broadcast codes and precoding; cellular and ad-hoc network topologies; OFDM and ultrawideband systems; and architectural issues.

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: In this section provide the software name (if any) data sheet according to this course.

a. Operating / Manufacturers' Manuals
b. Lab Manuals

******

A) Course Code **: 2428605 (T2428605/S2428605)**

B) Course Title **:** Technical Textiles

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

D) Rationale **:**

Textile products whose primary objective is to meet some technical requirements or functions are termed technical textiles. The use of high-technology products which offer enhanced performance, durability, hygienic conditions and aesthetics has become the need of the day. Technical textiles are being applied in a wide range of areas like healthcare, industrial applications, automotive industry, marine industry, fishing, agriculture, construction and packaging. During the past few years, the use of technical textiles has grown rapidly. The selection of the right material is very important while manufacturing technical textile products. The selection of material depends upon the required function, nature and severity. Therefore it is important to have appropriate knowledge about textile fibres in the light of current **climate change** and other global challenges as textiles in any form (fibre, yarn or fabric) provide excellent thermal and mechanical properties with low weight.

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

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

CO-1 Choose an appropriate technical textile product for the given applications.

CO-2 Utilize the knowledge of Textile-Reinforced Composite Material for the given end-use.

CO-3 Select relevant textile materials to produce technical textile products used for filtration and geo-textile.

CO-4 Apply textile fibre properties to produce automotive textiles and medical textiles.

CO-5 Recommend various textile products for yield enhancement in agriculture, protection and sports.

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** Lifelong learning	**PSO-1**	**PSO-2**
CO-1	3	1	1	-	-	-	1		
CO-2	3	1	1	-	-	-	1		
CO-3	3	1	1	-	1	-	1		
CO-4	3	1	1	-	-	-	1		
CO-5	3	1	1	-	1	-	1		

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

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

G) Teaching & Learning Scheme:

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				
2428605	Technical Textiles	02	01	-	02	05	04

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies, Lecture(L), Tutorial(T), Case method, Demonstrations, Video demonstration, Problem-based learning. 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= (1xCIhours) + (0.5xLIhours) + (0.5xNotionalhours)

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

H) Assessment Scheme:

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)	
2428605	Technical Textiles	30	70	20	30	--	--	150

Legend:

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

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

TWA: Term work & Self-Learning Assessment (Includes assessment related to student performance in assignments, seminars, microprojects, 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 assignments, micro-projects, seminars 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 for internal as well as external assessment may vary as per the requirement of the respective course. For valid and reliable assessment, the internal faculty should prepare a 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 the attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020-related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: T2428605

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Classify technical textiles based on the given applications. *TSO 1b.* Explain applications of technical textiles in different sectors. *TSO 1c.* List different fibres used for technical textiles with their applications. *TSO 1d.* Explain the characteristics of various fibres used for technical textiles. *TSO 1e.* Describe the applications of various high-performance fibres. *TSO 1f.* Explain different types of finishes applied on fabric to achieve functional properties.	**Unit-1.0 Introduction to Technical Textiles** 1.1 Definition, Classification, products, market overview and growth projections of technical textiles 1.2 Application of technical textile products in various sectors 1.3 Raw material used for technical textile 1.4 Characteristics and Physical properties of different fibre used for technical textile 1.5 Technical fibres, yarns and fabric structures 1.6 High-performance fibres: Ultra fine fibres, micro fibres, nano fibres, hollow fibres, aramid fibres, carbon fibres, glass fibres 1.7 Fabric finishing: Flame retardant finishes, Water and soil-repellent finishes and antimicrobial finishes	**CO1**
TSO 2a. Describe the applications of Textile-Reinforced Composite Materials. *TSO 2b.* Explain the role of textile fibres and matrix/resin in the composite. *TSO 2c.* Describe the manufacturing process of composites. *TSO 2d.* Exlain different techniques of fabric coating. *TSO 2e.* Classify fabric lamination.	**Unit-2.0 Textile – Reinforced Composite Materials** 2.1 Introduction, classification of composite materials 2.2 Reinforcement materials, Matrix/Resin 2.3 Manufacturing processes of composites 2.4 Application of composites, Composite testing 2.5 Lamination and Coating: Coating, Coating types and Coating techniques 2.6 Lamination: Definition, classification and application of Laminates	**CO2**
TSO 3a. Describe the characteristics of textile materials for the given type of filtration. *TSO 3b.* Describe the factors which influence the design or selection of filter fabrics. *TSO 3c.* List the characteristics required for the given type of geotextile. *TSO 3d.* Select the geotextiles for the given situation. *TSO 3e.* Describe the functions of given geotextiles. *TSO 3f.* State the advantages of using geotextile for the given application. Describe the characteristics of textile materials for the given type of filtration.	**Unit-3.0 Textiles in Filtration & Geo-Textiles** 3.1 Filtration: Definition, principles and mechanism of filtration, wet and dry filtrations, Textile materials infiltration 3.2 Selection criterion of textile for filtration 3.3 Characteristic properties of fibres, yarns and fabrics infiltration 3.4 Finishing treatments for filter fabric: Heat setting, Singeing, Raising, Calendaring, Chemical treatments 3.5 Geosynthetics: Introduction, Geo-Technical products 3.6 Geo-textiles: Definition, types, manufacturing process and properties 3.7 Functions of Geotextile: Separation, Drainage, Filtration, Reinforcement, Protection, Stabilization, Waterproofing, parameters influencing these functions 3.8 Application of Geotextiles	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 4a. Describe the essential properties required for seat covers, seat belts and airbags. TSO 4b. List different fibres used in automotive with their applications. TSO 4c. Describe the requirement of medical textiles. TSO 4d. Describe the characteristics of textile materials for the given type of medical textile application. TSO 4e. Classify medical textiles. TSO 4f. Identify applications of the medical textiles in the given situation.	**Unit-4.0 Automotive Textiles & Medical Textiles** 4.1 Introduction, Use of technical textiles in passenger cars, other road vehicles, trains and aircraft 4.2 Fibres used for automotive applications: upholstery, carpeting, pre-formed parts, seat belts, airbags, tyres, filters and engine compartment items 4.3 Manufacturing processes and application of technical textiles used for automotive 4.4 Medical Textiles: Introduction, classification and function of Medical textile product 4.5 Characteristics of fibre/yarn/fabric used for Medical textile 4.6 Application of Medical textile: Non-implantable materials, Extracorporeal devices, Implantable materials, Healthcare/hygiene products	**CO4**
TSO 5a. Describe the properties required for the given agro textiles. *TSO 5b.* List various applications of agro textiles for the given crop production. *TSO 5c.* State the advantages of using agrotextiles for the given application. *TSO 5d.* Describe the use of protective textiles with their applications. *TSO 5e.* Describe the use of sports textiles with their applications.	**Unit-5.0 Other Fields of Technical Textiles** 5.1 Agro textiles: Introduction, Properties required for agro textiles, application of agro textiles in Crop production, agro textiles for horticulture and floriculture, animal husbandry, fishing and aquaculture nets 5.2 Protective textile: Bulletproof fabric, fireproof fabric, chemical protective fabric, visual camouflage 5.3 Sports textiles: Helmets, hand gloves, sports shoes, balls	**CO5**

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: S2428605 Some sample suggested assignments, micro-projects and other activities are mentioned here for reference.

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

1. Prepare a report on technical textile products of different manufacturers.
2. Library/Internet survey of application of technical textiles.
3. Collect different fibres/filaments used in technical textile products.
4. Collect data on various types of geotextile manufacturing processes, properties and applications.
5. Collect data on the manufacturing company of filter fabrics and the price of the same.
6. Collect data on various medical textile products and sport textile products.

7. Explore the library/internet for production technologies being used for the production of Composite Materials and make a report.
8. Collect data on various types of products, manufacturing processes, properties and applications in transportation textiles.

b. Micro Projects:

1. Collect at least ten samples of a technical fabric (woven/knitted/nonwoven) used in different technical areas and prepare a booklet showing the special features for selecting the fabric for the relevant application.
2. Collect five different samples of medical textile products and sport textile products and prepare the features, properties and manufacturing process of collected samples.
3. Collect samples of geotextile and prepare a chart of product specifications.
4. Draw a detailed classification chart of fibre used in the technical textile industry with examples of each variety.
5. Collect the information on different fibres/filaments used in medical textiles by doing a local market survey and preparing a report.
6. Collect various samples of filter fabrics study the Physical and chemical properties of filter fabrics and prepare compile report.
7. Prepare a compiled report on raw material, structure, properties and end-use application of various high-performance fibres.
8. Prepare a sample book of different forms of technical textile products from the market.

c. Other Activities:

i. Seminar Topics:
   - Methods of manufacturing Composite materials
   - Applications of High-performance fibre
   - Different finishing treatment
   - Fabric coating and laminates.
   - Applications of fibres and textiles in technical textile products

ii. Visits: Visit nearby technical textile industry with modern types of machinery facilities and Prepare a report of the visit with special comments on modern machinery used, material used, single component/ batch production/ mass production and cost of production.

iii. Self-Learning Topics:

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use the appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of 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%	20%	20%	-	-	-
CO-2	10%	10%	20%	20%	-	-	-
CO-3	30%	30%	20%	20%	33%	-	-
CO-4	25%	25%	20%	20%	33%	-	-
CO-5	10%	10%	20%	20%	34%	-	-
Total Marks	**30**	**70**	**20**	**20**	**10**	**-**	**-**
			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 percentages 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 Introduction to Technical Textiles	12	CO1	18	6	6	6
Unit-2.0 Textile – Reinforced Composite Materials	05	CO2	07	3	2	2
Unit-3.0 Textiles in Filtration & Geo-Textiles	14	CO3	20	4	8	8
Unit-4.0 Automotive Textiles & Medical Textiles	12	CO4	18	4	6	8
Unit-5.0 Other Fields of Technical Textiles	05	CO5	07	3	2	2
Total	**48**	**-**	**70**	**20**	**24**	**26**

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

O) Suggested Assessment Table 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 Lectures, Tutorial, Case Methods, Group Discussions, Industrial visits, Industrial Training, Field Trips, Portfolio, Learning, Role Play, Live Demonstrations in Classrooms, Labs, 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:

(b) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Handbook of Technical Textiles	Richard A. Horrocks, Subhash C. Anand	Woodhead Publishing, India ISBN: 9781782424659
2.	Handbook of Medical Textiles	Bartels V	Woodhead Publishing, India ISBN: 9781845696917
3.	Geotextiles From Design to Applications	Koerner Robert	Woodhead Publishing, India ISBN: 9780081002216
4.	Handbook of Geotextiles	BTRA	Bombay Textile Research Association, Mumbai, ISBN: 9788176741323
5.	Agrotextiles: A Growing Landscape with Huge Potential	Geoff Fisher	Textile Media Services Lt, 2013 ISBN:9780957361621
6.	Industrial Applications of Textiles: Textile for Filtration and Coated Fabrics	Bajaj, P. and Sengupta, A.G.	The Textile Institute, 1985 ISBN: 9780900739729
7.	Textiles for Protection	Richard A. Scott.	The Textile Institute, CRC Press, 1st Edition, 2005, ISBN: 9780849334887
8.	Automotive Textiles	Mukhopadhyay, S.K. and Partridge, J.F.	The Textile Institute, CRC Press, 1999 ISBN: 9781870372213
9.	Wellington Sears Handbook of Industrial Textiles	Adanur. S	CRC Press, 1st Edition, 1995 ISBN: 9781566763400

(b) Online Educational Resources:

1. https://archive.nptel.ac.in/courses/116/102/116102057/
2. https://textileapex.com/
3. https://www.textileblog.com/category/technical-textile/
4. https://textileengineering.net/technical-textile-function-classification-and-application/http://ittaindia.org/

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: -

****

A) Course Code : 2428606 (P2428606/S2428606)

B) Course Title : Major Project

C) Pre- requisite Course(s) :

D) Rationale :

Project work plays a very important role in engineering education in developing core technical skills, soft skills and higher level of cognitive, psychomotor and affective domain skills. Major Project work is normally done when students have acquired sufficient knowledge, skills and attitude and are able to integrate all these, entirely in new situation or task to solve the problems of the industries/field agencies/etc. Through major project work, students get direct exposure to the world of work in their relevant field. They are intrinsically motivated to explore new things, new methods, new design, many more ideas and also develop out of the box thinking abilities, creative and innovative capabilities. It also develops many soft skills like confidence, communication skills, creative ability, inquisitiveness, learning to learn skills, lifelong learning skills, problem solving skills, management skills, positive attitude, ethics etc. Normally in a curriculum document, there is a mention of project work indifferent context. In situation one, project work is reflected as micro project under each and every course curricular detailing, in the form of Term work mentioned under different semesters. These projects are normally related to the developing skills in respective course of the specific programme. In the context of diploma programme in Bihar, minor project work will be carried out in Semester 5 with emphasis on project planning. Major project work is reflected as a course in the total programme structure, normally at 6thsemester depending on the requirement of the programme. Through major project, students try to bring the industrial/real world problems in institutional setting, may be in collaboration/ networking with industries/field agencies/enterprises as per the requirement of different diploma programmes.

E) Course Outcomes: After completion of the major project work, students will be able to –

- **CO-1** Integrate the knowledge (K), skills (S), attitudes (A)developed, in a new task or problem identified in the form of project work.
- **CO-2** Develop higher level of cognitive, psychomotor and affective domain skills relevant to the course/programme.
- **CO-3** Solve the industrial/real world problems/tasks by Integrating the generic skills/soft skills/employable skills with relevanttechnical skills.
- **CO-4** Develop thecapabilities and skills of innovativeness, creativity, resourcefulness, time management, problem solving abilities, interpersonal skills, pro-activeness, cost effectiveness, environment consideration and sustainability.
- **CO-5** Prepare the project report.

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	3	-	-	-	1		
CO-2	3	-	3	-	-	-	1		
CO-3	3	-	3	3	-	-	1		
CO-4	3	2	3	-	2	2	1		
CO-5	3	-	3	-	-	2	-		

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

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

G) Teaching & Learning Scheme:

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				
2428606	Major Project	-	-	08	04	12	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:

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)	
2428606	Major Project	-	-	20	30	50	100	200

Legend:

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

Under the minor project in fifth semester, project planning is almost over. The projects are identified and allocated to students. Teacher's role is important as they act as guide, facilitator, catalyser, motivator to promote brain storming, thinking, creativity, initiativeness and many other skills in the students. Teachers should help or guide continually to monitor whether the students are proceeding in the right direction as per outcomes to be attained.

It is also suggested that teachers are not supposed to guide and plan each and every step from the point of view of execution of the project, otherwise it will curb the creativity or thinking process of the students. Teachers have to see that he or she is able to create think tank for this fast-technological world of work for the growth of our country. Following points should be taken into consideration while implementing the major project work.
The following steps are undertaken under the major project-

1. Design, Development and Execution of the Major Project.
2. Quality of Project Report Writing and its Presentation.

1.0 Design, Development and Execution of Major Project:

Projects design, development, execution is done by the students under the guidance and feedback by respective teachers for attainment of courses specific outcomes, POs and PSOs.

Continual Monitoring, feedback and assessment mechanism on weekly progress/updates on action taken on different criteria and sub-criteria of the project work need to be planned for individual and team of students. Path breaking teachers who think out of the box are required to guide, monitor and evaluate the project work.

1.1 Unique Features of Major Project:

Following important characteristic features of project need to be given special emphasis during the implementation and evaluation of the major project work-

- Innovativeness
- Creativity
- Originality
- Pro-activeness
- Initiativeness
- Cost Effectiveness
- Resourcefulness
- Development of Soft Skills/Generic Skills
- Ethical Issues
- Environmental Considerations
- Simulated/Automated Industry's/Improvised Process
- Application or Utility in the World of Work.
- Relevance to the Curriculum
- Mapping of Outcomes of Project with Pos and PSOs (if applicable)

- Feasibility of Implementation of the Project

2.0 Quality of Project Report Writing and its Presentation:

Following points need to be taken care of during report writing, its implementation and evaluation-

- Report writing as per prescribed format
- Clarity of outcomes
- Innovativeness
- Presentation of Data
- Data Analysis, Interpretation and Result
- Quality of Product/Prototype

2.1 Project Report Writing:

The suggested format of the project report is mentioned below for teacher's and students' reference:

i. Problem Statement/ Project Title
ii. Abstract
iii. Literature Review
iv. Outcomes of the Project
v. Project Planning, Design and Development
vi. Methodology
vii. Implementation and Testing
viii. Result and its Interpretation
ix. Summary
x. References / Bibliography

2.2 Presentation & Discussion:

Quality of presentation of data need to be ensured using the following criteria -

- Clarity in Communication and Presentation
- Voice Audibility
- Use of Media and Methods
- Satisfying the Queries of Audience
- Attainment of Outcomes

2.3 Project's Potential:

Futuristic scope and recommendation for further studies related to project may be assessed from the following criteria -

- Papers Published or Award Received
- Exhibition or Display or Showcase of Project in Competition or Exhibition or Tech Fest
- Evaluation of Working/Testing of Projects or Prototype
- Relevance and Applications in the World of Work
- Recognition in any Form
- Related Areas/Sub Areas for Further Studies

J) Assessment of the Major Project:

For objective, valid and reliable assessment, different tools of assessment such as a checklist, rating scale, assessment rubric, observation schedule, portfolio assessment, incidental records etc. need to be prepared. Even the students may been courage to adopt self-assessment techniques using the assessment rubrics.

The students need to be assessed continuously based on the suggested below mentioned assessment criteria at project planning stage. The project guide must prepare detailed rubric(s) for each criteria to have more valid and reliable assessment. Criteria of assessment of major project work are mentioned below.

Assessment Scheme for Major Project

S. No.	Suggested Assessment Criteria	Suggested Weightage (%)
1.	**Project Planning during Minor Project Work** 1.1 Identification of Area/Problem Statement 1.2 Literature Survey 1.3 Formulation of Project Title 1.4 Clarity in Formulation of Outcomes of The Project 1.5 Preparation of Synopsis 1.6 Presentation of Synopsis	30
2.	**Design, Development and Execution of the Project**. 2.1 Unique Features of Major Project	45
3.	**Quality of Report Writing and Presentation**. 3.1 Report Writing 3.2 Presentation & Discussion 3.3 Project's Potential	25
	TOTAL	100

******

A) Course Code : **2428607(T2428607)**

B) Course Title : Basics of Intellectual Property Rights (IPR) (FCT, TE)

C) Pre- requisite Course(s) :

D) Rationale :

Many of the entrepreneurs make many mistakes in the process of setting up their enterprise. This course will prepare the diploma students to avoid such mistakes. In this course, the diploma student will learn to protect their work/assets/product which is otherwise called as their intellectual property. This includes Patents, Copyrights, Trademarks, Geographical Indications, Industrial designs, layout of Integrated Circuit design, Trade and Trade secrets. This course is designed to educate students so that they will be able to protect their intellectual property/ work/ product based on appropriate classification mentioned.

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** Realize the need and significance of IP and IPR in India.
- **CO-2** Protect your innovative product/work under Patent, Copy right, Trademark, Geographical Indication and Plant variety and Farmer's right
- **CO-3** Protect your innovative product under Industrial Design/ Layout design of Integrated Circuit/Trade secret.

F) Suggested Course Articulation Matrix (CAM):

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

Course Code	Course Title	Scheme of Study (Hours/Week)				
		Classroom Instruction (CI)		Notional Hours (TW+ SL)	Total Hours (CI+TW)	Total Credits (C)
		L	T			
2428607	Basics of IPR	02	-	-	02	02

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.

Assessment Scheme:

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)	
2428607	Basics of IPR	25	-	-	-	-	-	25

Legend:

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

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

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.

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: T2428607

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain the concept of Intellectual Property (IP) and Intellectual Property Right (IPR). *TSO 1b.* Enlist the types of IPR and the type of protection it offers to a product. *TSO 1c.* Explain the enforcement of IPR *TSO 1d.* Name the legislations covering different types of IPRs in India.	**Unit-1.0 Introduction to IPR and its Enforcement** 1.1 Concept of IP and IPR and its importance 1.2 Types of IPR – Patent, Copyright, Trademark, Geographical Indications, Industrial designs, Layout design of Integrated Circuit and Trade secret 1.3 Enforcement of IP on a given product 1.4 Legislations covering IPRs in India	**CO1**
TSO 2a. Explain the need and significance of Copyright/Trademark/GI/ Plant variety and farmer's right *TSO 2b.* Enlist the works entitled for protection under Patent/Copyright/Trademark/GI/ Plant variety and farmer's right *TSO 2c.* List the work & protected under patent/ copyright/Trademark/GI/ Plant variety and Farmer's right *TSO 2d.* Mention the legislation set up in India and fees applicable for getting Patent/Copyright/Trademark/GI/ Plant variety and Farmer's right. Also mention the tenure of protection	**Unit-2.0 Patent, Copyright, Plant Varity and Farmer's Right and Geographical Indications** 2.1 Patent - Need and significance of patent, Types of Patent, tenure, legislation and organization set up in India and fees and brief procedure of patent filing in India 2.2 Copyright -Need and significance of Copyright, entitlement to protection of copyright, works protected, tenure, legislation and organization set up in India and fees 2.3 Trademark - Need and significance of trademark, entitlement to protection of trademark, works protected, tenure, legislation and organization set up in India and fees, Procedure for filing application for Trademark, Passing and infringement of trademark 2.4 Geographical Indications (GI)-Need and significance of GI, entitlement to protection of GI, works protected, tenure, legislation and organization set up in India and fees, Passing and infringement of GI 2.5 Plant Variety & Farmer's Rights – Need and significance, entitlement to protection of plant varieties, register able plant varieties in India, Duration of protection for a registered new plant variety	**CO1, CO2**
TSO 3a. Explain the need and significance of Industrial Design/ Layout design of Integrated Circuit/Trade secret. *TSO 3b.* Enlist the works entitled for protection underof Industrial Design/ Layout design of Integrated Circuit/Trade secret. *TSO 3c.* List the work protected under Industrial Design/ Layout design of Integrated Circuit/Trade secret. *TSO 3d.* Mention the legislation set up in India and fees applicable for getting Industrial	**Unit-3.0 Industrial Designs, Layout Design of Integrated Circuits, and Trade Secrets** 3.1 Industrial Designs -Need and significance of Industrial Designs, entitlement to protection of designs, works protected, tenure, legislation and organization set up in India and fees, Infringement of design right 3.2 Layout design of Integrated Circuit - Need and significance of protection of layout designs for Integrated Circuits. entitlement to protection,	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
Design/ Layout design of Integrated Circuit, also mention the tenure of protection *TSO 3e.* Explain the strategies to protect trade secret in India with 2 examples	works protected, tenure, legislation and organization set up in India and fees, and Infringement 3.3 Trade secret- Need and significance of Trade secret protection. entitlement to protection, works protected, tenure, legislation and organization set up in India and fees, strategies to protect trade secret in India	

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

J) Suggested Term Work/ Activities 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.

1. A product is always protected simultaneously by more than one type of IPR and there is always the overlapping of rights. Considering the example of purple pill or any other product, highlight the enforcement of IP particularly Patent, Copyright, Trademark, design, and trade secret.
2. Mr. A has discussed an idea of a long story with Mr. B and Mr. C. Later, Mr. C has written a Novel based on discussion. Who will be author and owner of this novel? Analyze and answer
3. Mr. A has written a book on "How to arrange library books". Mr. B reads that book and arranges the books as discussed in that book. Whether Mr. B will be liable for copyright infringement? Analyze
4. Mr. Ram has created and designed an innovative website. Analyze the appropriate protection mechanism/s for that website. How to protect IC layout in India? Analyze and answer.
5. Mention the role played by a patent document in innovation, R &D
6. Is it possible to register the shape and configuration of a shock absorber under Industrial Design act in India? Analyze and answer

b. Micro Projects:

2. Scroll through https://ipindia.gov.in/ to explore about Patents, Industrial designs, Trademarks and Geographical Indications and prepare a report.
3. Scroll through https://ipindia.gov.in/ and prepare a checklist for design applications
4. Do internet survey to analyze the case studies related to Copyright, Trademark, Trade secret and GI

c. Other Activities:

1. Seminar Topics:
   - Different forms of IPR and its need.
   - Types of Patent applications and Patent filling procedure
   - Relevance of different types of IPR to various professions.
   - Types of Trademarks and Infringement of Trademark
   - Differentiate GI with Trademark

2. Visits: Visit nearby company/industry and prepare a report/Case study of visit with special comments on how they have patented their product, registered their company's logo under trademark, protected their product design under design act and strategy used by them to protect their trade secret if any.

3. Self-Learning Topics:
   - Patent filing procedure.

- Criteria for registering Industrial design in India
- Strategies to protect trade secret
- GI of various products
- Types of Trademarks and importance
- Trade secret protection – Case study of Coca-cola

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, 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.

L) List of Major Laboratory Equipment, Tools and Software:(If Any)

S. No.	Name of Equipment, Tools and Software	Broad Specifications
2.	High end computers	Processor Intel Core i7
3.	MS Office	-

M) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers	Ramakrishna B and Anil kumar H.S.	1 January 2017Notion Press ISBN-10 1946556319 ISBN-13 978-1946556318
2.	Intellectual Property Law	Narayan P.	1 January 2001, Eastern Law House Private Ltd ISBN-10 8171772684, ISBN-13 978-8171772681
3.	Intellectual Property Rights: Text and Cases	Radhakrishnan R., Balasubramanian S	July 30, 2008, Excel Books (July 30, 2008) ISBN-10 : 8174466096 ISBN-13 : 978-8174466099
4.	Law Relating To Intellectual Property	WasehraB.L	January 2016, Universal Law Publishing ISBN-13 978-9350350300
5.	Intellectual Property Law	Meenu Paul	Allahabad Law Agency ISBN-10 : 8190286714 ISBN-13 : 978-8190286718
6.	Law of Intellectual Property	Myneni S. R.	Asia Law House (1 January 2019) ISBN-10 : 9388437233 ISBN-13 : 978-9388437233

(b) Online Educational Resources:

1. https://ipindia.gov.in/
2. https://nptel.ac.in/courses/109106137
3. https://books.openedition.org/iheid/652?lang=en

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. WIPO Intellectual Property Handbook
2. The Intellectual Property Handbook: A Practical Guide for Franchise, Business, and IP Counsel Second Edition by Christopher P. Bussert, James R. Sims III
3. IPR Handbook for Pharma Students and Researchers Parikshit Bansal, PharmaMed Press, 2015

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A) Course Code : 2400408 (T2400408)

B) Course Title : Employability Skills Development (Common for all Programmes)

C) Pre- requisite Course(s) :

D) Rationale :

Education may only be enough to qualify for a job, but employability skills are the major criteria to be considered for a job role. Employability skills are building blocks of any career and they equip one to carry out roles in the company to the best of their ability. Employers usually check these employability skills before hiring. These sets of job-readiness skills are behaviors that are necessary for every job and are essential attitudes that enable students to grow in their careers. Employers value employability skills because they regard these as indications of how their employees will get along with other team members and customers, and how efficiently they will be able to handle the job performance and career success. Employers like to hire a technical expert who also displays well-rounded employability skills.

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 Build resume and showcase portfolio for placement activity.

CO-2 Face interviews and participate effectively in Group Discussions.

CO-3 Apply engineering tools in work situations and societal 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/ Development of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainability and Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	3	-	-	3	-	-	2		
CO-2	3	-	-	-	2	2	3		
CO-3	3	-	-	3	3	2	2		

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

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

G) Teaching & Learning Scheme:

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				
2400408	Employability Skills Development	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:

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)	
2400408	Employability Skills Development	25	-	-	-	-	-	25

Legend:

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

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

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: T2400408

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Perform SWOT analysis and reflect. *TSO 1b.* Develop skills in carrier planning & goal setting *TSO 1c.* Build a Resume using Internet formats. *TSO 1d.* Develop and Design portfolios. *TSO 1e.* Maintain good grooming attire. *TSO 1f.* Introduce oneself to others. *TSO 1g.* Develop a personal website.	**Unit-1.0 Goal Setting** 1.1 Career planning, SWOT 1.2 Resume using Internet formats. 1.3 Showcase portfolios. 1.4 Personal grooming. 1.5 Self-Introduction. 1.6 Website Development.	**CO1**
TSO 2a. Face interviews and E- Interviews confidently *TSO 2b.* Participate in group discussions. *TSO 2c.* Use Social media for personal enrichment &Netiquette *TSO 2d.* Manage self for higher growth. *TSO 2e.* Use body language for effective communication *TSO 2f.* Manage Emotions for personal growth	**Unit-2.0 Capacity Development** 2.1 Interview Skills 2.2 Group Discussion – Do's & don'ts, leadership, Teamwork, how to interrupt, synthesis, and analysis of topics. 2.3 Social Media for Personal Enrichment 2.4 Body language 2.5 Self-Management. 2.6 Emotional Intelligence	**CO2**
TSO 3a Develop & Maintain Social Contacts. TSO 3b Engage in Social Service projects. TSO-3c Collaborate for mutual advantage. TSO 3d Apply QC-Tools in work situations. TSO 3e Practice Lean Manufacturing Techniques for Production and Operations	**Unit-3.0 Utilizing Potential** 3.1 Social Networking 3.2 Social Engagements, Volunteering 3.3 Collaboration& Team-work. 3.4 QC-Tools – Check sheets, Fishbone Diagram, Histogram, Pareto chart, Control-chart, Scatter Diagram, Stratification, 3.5 Lean Manufacturing, Kanban, Kaizen, Five S, Poka-yoke, Quality Circle	**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:

1 Build a resume for Placement Activity.

2 Prepare letters for job applications.

b. Micro Projects:

1. Prepare collage for personal grooming.
2. Develop a showcase portfolio.
3. Prepare a collage of different gestures and postures of Body Language.
4. Apply Five-S in a work situation.
5. Arrange Mock Interviews, appear, and video record. Reflect on your performance.
6. Organize Group discussions on current topics and video record. Reflect on your performance

c. Other Activities:

1. Seminar Topics:
   - Emotional Intelligence.
   - 21st Century Skills.
   - Multitasking

2. Visits: Visit nearby Job Fairs, Career Guidance Fairs, etc.

3. Self-Learning Topics:

   - Use of social media.
   - Self-introduction.
   - Self-grooming.
   - QC Tools.
   - Lean Manufacturing,
   - Emotional Intelligence.

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%	-	-	-	-	-	-
CO-2	40%	-	-	-	-	-	-
CO-3	30%	-	-	-	-	-	-
Total Marks	**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 percentages 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): (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:

S. No.	Name of Equipment, Tools and Software	Broad Specifications
1.	Group Discussion Tables and chairs	Round Table with seating arrangement for 15 person
2..	Mock Interviews infrastructure	2 parallel mock interview set up with recording facility.
3.	Ear phones	Compatible with mobile phones
4	Headphones	Compatible with laptop/desk top
5	Blue tooth	Compatible with mobile phones.
7.	CC TV Camera	Compatible to record presentations and addresses.
8.	Podium	For presentations on stage.
9.	Public address system	For public meetings.
10.	Full Glass Mirrors	For monitoring Body Language

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Employability Skills Skills for Employability	Dr. M. Sen Gupta	Innovation Publication Pvt Ltd, 2020, ISBN: 978-81-933819-1-5
2.	Employability Skills	Dr. Nishith Rajaram Dubey, Anupam Singh	Indra Publishing House, 2023 ISBN - 978-93-93577-68-9
3.	Organizational Behavior	A. K. Chitale, Rajendra Prasad Mohanty and Dr Nishith Dubey	PHI Learning Pvt Ltd ISBN 978-81-203-4696-3
4.	Managerial Skills	Dr Nishith Dubey & Prof Gitanjali Shrivastava	Shiva Prakashan, Indore, India,2010, ISBN 81-7677-100-7,
5.	Body Language	Allan Pease	Pease International PTY. Ltd Australia
6.	Production and Operations Management Goods & Services approach	Dr S.V Deshmukh, Dr A. K. Chitale and Dr Nishith Dubey	Archers & Elevators publishing house, Bangalore, ISBN 9789386501197
7.	Emotional Intelligence	Daniel Goleman	Word Press.Com, 9789382563792
8.	How to win friends and influence people	Dale Carnegie	Srishti Publishers & Distributors, Delhi, India

(b) Online Educational Resources:

1. **4-Year Plan for Career Success:**
   https://eng.umd.edu/sites/clark.umd.edu/files/4%20Year%20Plan%20For%20Career%20Success_Categorized_1.pdf

2. **CAREER DEVELOPMENT GUIDE** https://www.engineersaustralia.org.au/sites/default/files/content-files/2016-12/career_development_guide_may_2014.pdf
3. **Tips for successful career planning** tips://www.aryacollege.in/tips-for-successful-career-planning-in-2021/
4. **Career Planning** – Complete Guidehttps://www.mygreatlearning.com/blog/what-is-career-planning/
5. **Build Resume:** https://www.themuse.com/advice/how-to-make-a-resume-examples
6. **Build Resume** https://resumegenius.com/blog/resume-help/how-to-write-a-resume
7. **Body Language:** https://ubiquity.acm.org/article.cfm?id=3447263
8. **Group Discussions:** https://brightspeaking.com/en/how-to-effectively-participate-in-a-group-discussion/
9. **Carrier planning & goal setting**: https://www.hays.com.au/career-advice/career-development/setting-career-goals
10. **Carrier planning & goal setting:** https://www.thebalancemoney.com/step-by-step-guide-to-setting-career-goals-2059883
11. **Collaboration & teamwork:** https://www.indeed.com/career-advice/career-development/teamwork-and-collaboration
12. **Interview skills:** https://www.youtube.com/watch?v=lKCTS9dY4h4

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(c) Others:

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