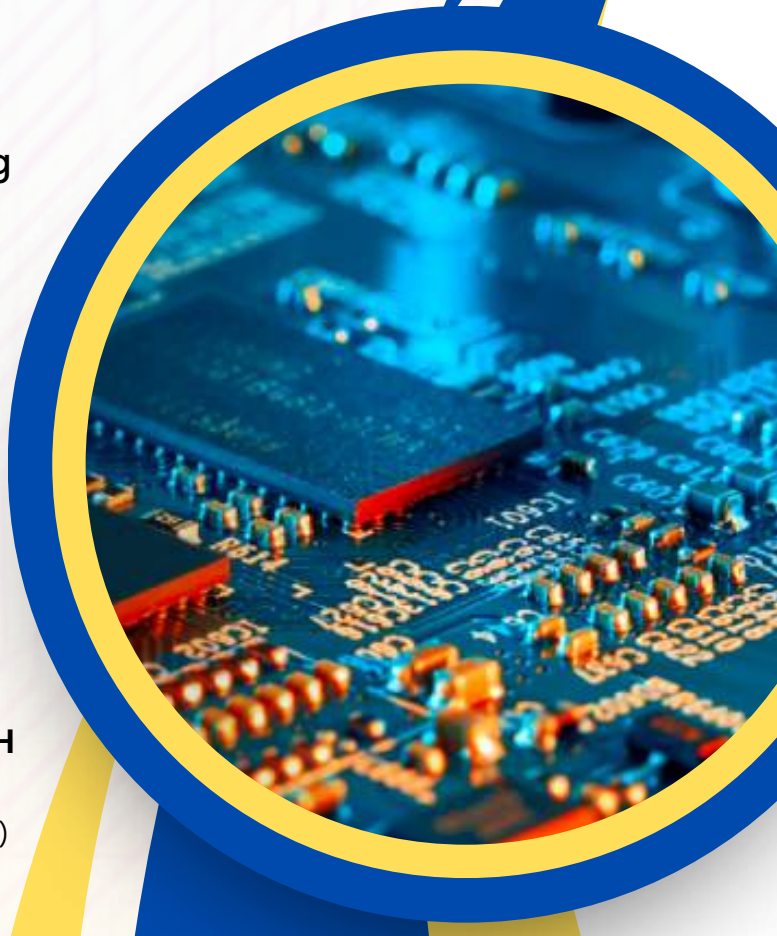
Curriculum

M.Tech VLSI & Microelectronics

July, 2025

School of
Engineering and Technology

Department of
Electrical & Electronics Engineering
Education



Deemed to be University under Distinct Category

NATIONAL INSTITUTE OF TECHNICAL TEACHERS' TRAINING AND RESEARCH (NITTTR), BHOPAL

(Deemed to be University under Distinct Category)

Ministry of Education, Government of India

Shamla Hills, Bhopal – 462 002

Madhya Pradesh, India

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Contents

Preface

National Institute of Technical Teachers' Training and Research (NITTTR), Bhopal is a unique premier institution under the MoE, GOI for improving the quality of the higher education system in India, especially the technical education system of the country. It was established in 1965 as the Regional Training Institute (RTI) for the western region. Later in 2003, it was upgraded as NITTTR, and recently in 2024, NITTTR was granted the status of a Deemed University under Distinct Category.

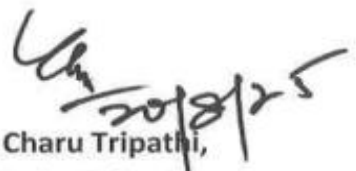
It is to mention here with great pride and immense pleasure that NITTTR Bhopal has launched 05 M. Tech. programmes in engineering, one MBA programme,2 MSc programmes. 09 PG Diploma and 03 diploma programmes from 2025-26. Two batches have already been passed out in the Diploma in Semiconductor Packaging (OSAT/ATMP). The institute has also developed the centre of excellence in Siemens with 11 High-Tech Laboratories, a Centre of Excellence for OSAT/ATMP and a Centre for Experiential learning (CEL) for providing hands-on experience to the learners. The PhD programme in Schools of engineering, sciences, management and creative education &liberal arts has already been launched.

The learner-centric outcome-based curricula have been developed for all 08 PG programmes. These curricula with multidisciplinary approach are aligned to the philosophy of NEP:2020 and NCrF, with provision of ME&ME, flexibility and holistic development, catering to nurture intellectual, emotional, psychological, social, moral and physical wellbeing of the learners to be good human being and ensuring success in profession of their choice in industry/research/academic/start-ups.

NEP recommends integrating vocational/technical education with general education and strengthening industry-academia collaboration in HEIs. Experiential learning is integrated in the curriculum to be practiced by the learners through hands-on experience at all high-tech labs and centres of excellence at the institute. Project/ problem based learner centric flexible learning environment is propagated for life-long learning, even from their workplace.

By formally embedding unique features and OBE principles into our M. Tech, MSc. and MBA programmes, NITTTR is committed to nurturing competent, responsible and forward-thinking, futuristic educators, technologists & researchers. This initiative complements our broader mission of fostering and integrating pedagogical excellence into engineering, science and management streams for quality-driven education.

The effective implementation of these curricula using advanced pedagogical methods and assessment reforms will provide high-quality, learner-centric education that will meet the expectations of industry, academia and research.



Prof. (Dr.) Chandra Charu Tripathi,
Project Director
NITTTR, Bhopal

2. Introduction:

The M. Tech programme in VLSI and Microelectronics is a cutting-edge academic initiative designed to equip learners with comprehensive knowledge and practical skills in semiconductor technology. Through a blend of theoretical coursework, hands-on laboratory exercises, and research projects, learners delve into semiconductor physics, integrated circuit design, fabrication techniques, and emerging trends. Led by expert faculty and supported by state-of-the-art facilities, this program prepares learners for careers at the forefront of innovation in fields such as electronics design, semiconductor manufacturing, and academic research, fostering the next generation of leaders in VLSI and Microelectronics.

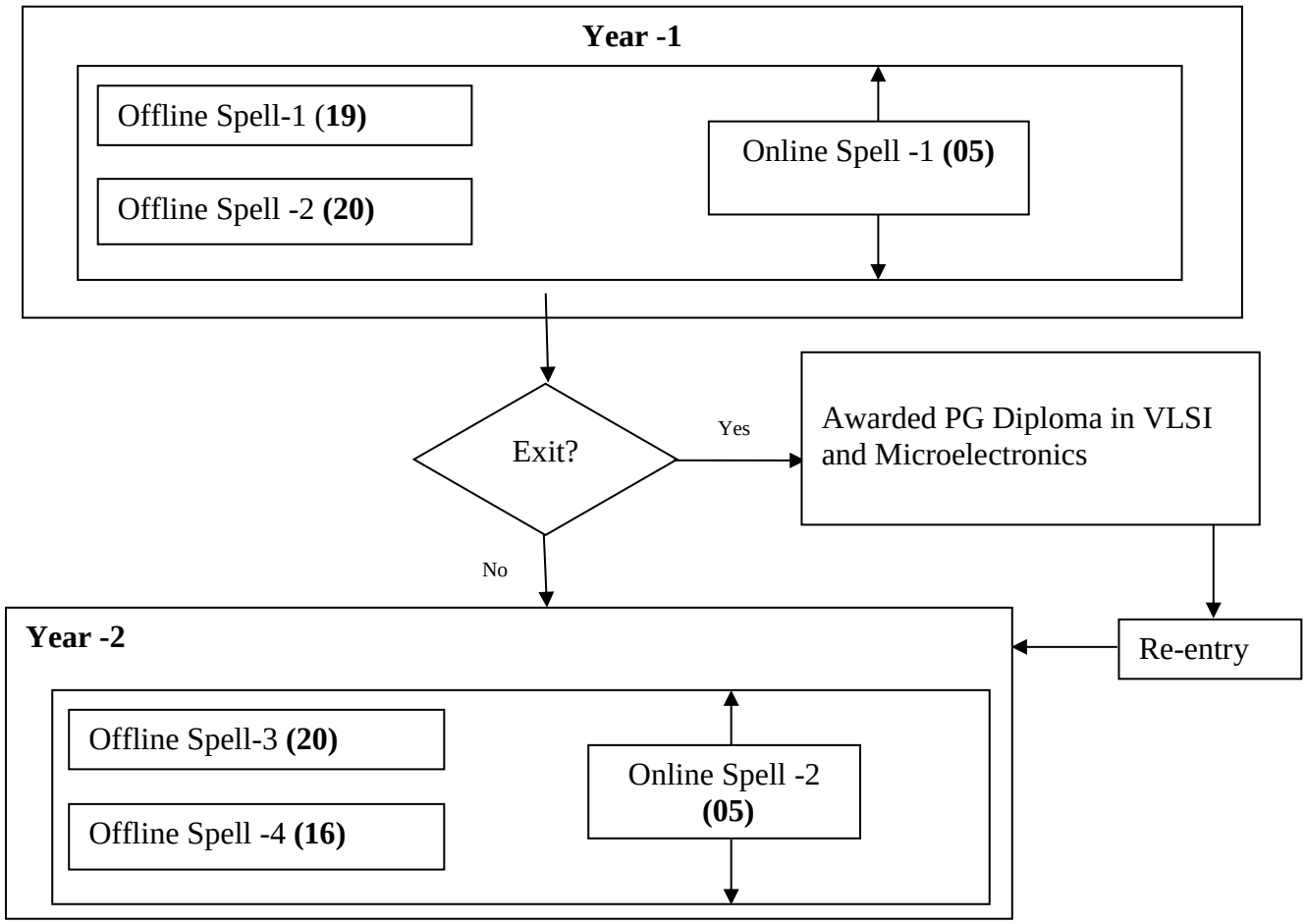
3. Approach for Scientific Design & Development of Curriculum:

The curriculum is designed after identifying the current job title of the industry where pass-out students will be absorbed. Later, different job skills required for the professionals are identified. These job skills are further mapped with the courses to be offered. Course outcomes for all the courses are also identified based on the job skills required for the professionals.

4. Unique Features of the Curriculum:

- The programme is aligned with the philosophy and requirements of NEP and NHEQF.
- Outcome-Based, learner centric curriculum with comprehensive and balanced mix of different category of courses as mentioned in Table-1.
- The duration of M.Tech. Programme is two academic years, (4 offline spells and 2 online spells running in parallel with offline spells). The online spell-1 will run parallelly with offline spell 1 and 2. The online spell-2 will run parallelly with offline spell 3 and 4. The representation of offering of programmeis mentioned in Figure 1. Each offline spell is of 15 weeks duration. This includes one week end-term examination and 5 weeks of mandatory classroom/lab based study. The total credit and marks are mentioned in Table-2
- The provision for Recognition of Prior Learning is also included.
- Dynamic curriculum with option of inclusion of diversified courses as per the changing needs of the industry.
- Holistic and multidisciplinary educational programme
- Inter-disciplinary research based project, emphasis on project management and finance, creativity and innovation, concern for professional ethics, environment and society etc.
- Credit-based courses with an option of Multi- Entry and Exit and projects in community engagement, environmental education, and Bhartiya Knowledge System.
- Recognition of identified SWAYAM / NPTEL courses.

Figure -1 Representation of Offering of Programme



5. Vision & Mission Statements of the Institute:

Vision: To be the world class leader for integrated development of technical education and training systems catering to the changing needs while achieving highest level of client satisfaction, quality, professional values and contributing to technological, economic and social development of the country.

Mission: NITTTR Bhopal will act as a centre of excellence to: Intensify teacher education for improving quality and performance of technical institutions. Make the technical education a vibrant learning system for producing competent manpower to steer technological and economic development. Provide a wide spectrum of client driven services and products through various modes. Strengthen networking and synergic partnership with technical institutions; industries, field agencies, and premier national and international organizations. Promote creativity, innovations, research and development, professional management practices, concept of learning organization, benchmarking and economics of education amongst client systems. Enthuse the spirit of professionalism, values and work ethics, networking and partnership with industry and other organizations and technical institutions.

6. Vision & Mission Statements of the Department:

Vision: Continue to innovate processes and products to usher in developments in electrical/electronic engineering education, keeping excellence in focus and deliver quality services to match the needs of the technical education system, industry and society.

Mission:

- Offer long-term and short-term programmemes related to electrical and electronics engineering and technical education for quality improvement through blended and other modes.
- Undertake researches in emerging areas of electrical and electronics engineering to enhance employability of the graduates.
- Undertake researches to develop, review and modify curricula to match the needs of electrical & electronics engineering and allied programmemes to enhance employability of the graduates.
- Undertake Outcome-Based Curriculum Development in electrical & electronics and allied disciplines.
- Develop different types of learning resources to fulfil the needs of electrical and electronics engineering and engineering education.
- Undertake consultancy and extension services to external agencies with a view to help society related to electrical and electronics engineering education.
- Network with industries, national and international institutions, R & D, community and service organisations for synergic partnership.

7. Programme Educational Objectives (PEOs):

PEO 1: Have successful professional careers in educational institutes.

PEO 2: Have successful technical/professional careers in Semiconductor industries, research & other organizations.

PEO 3: Pursue higher studies and continue their professional development.

PEO 4: Manage chip-level solutions using state-of-the-art technologies.

PEO 5: Be a successful entrepreneur providing services in VLSI Design, Semiconductor Technology & Packaging and allied areas.

8. Programme Outcomes (POs): -As per NBA

PO-1 An ability to independently carry out research /investigation and development work to solve practical problems.

PO-2 An ability to write and present a substantial technical report/document**.**

PO-3 Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO-4 Develop semiconductor package using design tools.

9. Employment Potential:

Sample Employment and self-employment avenues are mentioned below-

9.1. Employment Avenues:

- Academician
- Scientist
- VLSI Design Engineer
- Microelectronics Engineer
- ASIC Design Engineer
- Analog/Mixed-Signal Circuit Designer
- FPGA Engineer
- SoC (System-on-Chip) Architect
- Semiconductor Process Engineer
- Research and Development Engineer in semiconductor
- Semiconductor Packaging Engineer
- Semiconductor Device Engineer
- Product Engineer (Semiconductor)

9.2. Self-Employment Avenues:

- Freelance Design and Consulting in Chip Design Electronic Design Automation (EDA) Tools
- Product Development and Prototyping
- Semiconductor Startups
- Training and Education
- Research and Development (R&D) in the area of Semiconductors

10. Features of M. Tech. Programme in VLSI and Microelectronics

The M. Tech in VLSI and Microelectronics programme is strategically aligned with India's Semiconductor Mission, aimed at building a robust semiconductor manufacturing ecosystem within the country. It supports the national vision of attracting semiconductor industries to establish Assembly, Testing, Marking, and Packaging (ATMP) or OSAT (Outsourced Semiconductor Assembly and Test) units in India. The programme features state-of-the-art laboratories equipped with advanced EDA tools and facilities focused on semiconductor ATMP/OSAT, positioning it among the most advanced setups in the country.

What sets this programme distint is its alignment with the core mandate of NITTTR Bhopal—to enhance curriculum development, pedagogy, and technical teacher training. It not only equips students with cutting-edge technological skills but also fosters the development of high-quality teaching professionals, contributing to India's journey towards becoming an Atmanirbhar Bharat.

Programme Structure (PS) with Teaching & Learning and Assessment Scheme:

1.	**Title of Programme**	:	M. Tech. in VLSI and Microelectronics
2.	**Board of Studies**	:	VLSI and Microelectronics
3.	**Duration of Programme**	:	Two Years
4.	**Entry Qualification**	:	B. Tech./ B.E.
5.	**Total Marks**	:	3840
6.	**Total Credits**	:	85
7.	**Total Number of Courses**	:	22

Summary of Credits and Marks

S. No	Spell	Credits	Total Marks
Year -1			
1.	Offline Spell - 1	20	850
2.	Offline Spell –2	20	830
3.	Online Spell – 1 (PD& NEP)	05	250
Total		**45**	**1930**
Year-2			
4.	Offline Spell - 3	19	860
5.	Offline Spell - 4	16	800
6.	Online Spell – 2 (PD & NEP)	05	250
Total		**40**	**1910**
Grand Total		**85**	**3840**

Category wise Courses

S. No.	Course Category	Abbreviations	Number of Courses	Total Credits
1.	Programme Core Courses	PCC	07	27
2.	Programme Elective Courses	PEC	02	07
3.	Stream Specific Diversified Courses (if applicable)	SSC	03	11
4.	Open Elective Courses (Common Basket)	OEC	-	-
5.	Project, Dissertation	PD	03	29
6.	Pedagogy Courses	PC	04	08
7.	NEP Courses	NEP	03	03
Total			**22**	**85**

VLSI and Microelectronics - VMEL

Teaching & Learning and Assessment Scheme (Year – 1)

Offline Spell – 1

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
VMEL01 (MSCPST04)	PCC	**Physics of Semiconductor Devices**	30	15	-	45	90	03	30	70	20	-	-	-	120
VMEL02	PCC	**IC Fabrication Technology**	45	15	45	15	120	04	30	70	20	-	20	30	170
VMEL03	PCC	**Digital CMOS IC Design**	45	15	45	15	120	04	30	70	20	-	20	30	170
VMEL04	PEC	**Programme Elective Course -1**	45	15	45	15	120	04	30	70	20	-	20	30	170
CSEB05	PCC	**Basics of Artificial Intelligence and Machine Learning**	30	15	45	30	120	04	30	70	20	-	20	30	170
NEP01-05	NEP*	**NEP Courses**	15	-	-	15	30	01	25	-	25	-	-	-	50
Total			**210**	**75**	**180**	**135**	**600**	**20**	**175**	**350**	**125**	**-**	**80**	**120**	**850**

Legends:

Course Category: Programme Core Courses (PCC), Programme Elective Courses (PEC), Stream Specific Diversified Courses (SSC), Open Elective Courses (OEC), Project (PD), Dissertation (PD), Pedagogy Courses (PC), NEP Courses (NEP)

Programme Elective Course -1: Semiconductor Packaging (VMEL04)

***Basket of NEP Courses:** Sports, Yoga & Meditation (NEP01)/ Open Educational Resources (NEP02)/ Professional Ethics (NEP03)/ Financial Literacy (NEP04)/ Engineering Economics (NEP05)

Offline Spell – 2

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
VMEL05	PCC	**Advanced Microcontrollers**	45	15	45	15	120	04	30	70	20	-	20	30	170
VMEL06	PCC	**Analog and Mixed Signal IC Design**	45	15	45	15	120	04	30	70	20	-	20	30	170
VMEL07	PEC	**Programme Elective Course -2**	45	15	-	30	90	03	30	70	20	-	-	-	120
VMEL08-10	SSC	**Stream Specific Diversified Course – 1**	45	15	45	15	120	04	30	70	20	-	20	30	170
PD01	PD	**Project**	-	-	45	105	150	05	-	-	200	-	-	-	200
Total			**180**	**60**	**180**	**180**	**600**	**20**	**120**	**280**	**280**	**-**	**60**	**90**	**830**

Legends:

Course Category: Programme Core Courses (PCC), Programme Elective Courses (PEC), Stream Specific Diversified Courses (SSC), Open Elective Courses (OEC), Project (PD), Dissertation (PD), Pedagogy Courses (PC), NEP Courses (NEP)

Programme Elective Course -2: Hybrid Circuit Packaging (VMEL07)

Stream Specific Diversified Course- 1: Reliability and Yield Engineering (VMEL08)/ CAD for VLSI (VMEL09)/ RF IC Design (VMEL10)

* All the Stream Specific Diversified Courses (SSC) have to be chosen from any one basket only. (Out of the 2/3/4 basket identified) Each basket will have 2 to 3 courses.

Online Spell –1

The online spell -1 will be offered parallelly with offline spell -1 and offline spell -2

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
PC01	PC	**Research Methodology**	30	-	-	30	60	02	30	50	20	-	-	-	100
PC02	PC	**Curriculum & Assessment**	30	-	-	30	60	02	20	30	50	-	-	-	100
NEP06	NEP	**Indian Knowledge System (IKS)**	15	-	-	15	30	01	25	-	25	-	-	-	50
Total			**75**	**-**	**-**	**75**	**150**	**05**	**75**	**80**	**95**	**-**	**-**	**-**	**250**

Legends:

Course Category: Programme Core Courses (PCC), Programme Elective Courses (PEC), Stream Specific Diversified Courses (SSC), Open Elective Courses (OEC), Project (PD), Dissertation (PD), Pedagogy Courses (PC), NEP Courses (NEP)

Year – 2

Offline Spell – 3

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
VMEL11	PCC	**HDL Based Design & FPGAs**	45	15	45	15	120	04	30	70	20	-	20	30	170
VMEL12-14	SSC	**Stream Specific Diversified Course – 2**	45	15	45	15	120	04	30	70	20	-	20	30	170
VMEL15-17	SSC	**Stream Specific Diversified Course – 3**	45	15	-	30	90	03	30	70	20	-	-	-	120
PD02	PD	**Dissertation Part -I**	-	-	90	150	240	08	-	-	300	100	-	-	400
Total			**135**	**45**	**180**	**210**	**570**	**19**	**90**	**210**	**360**	**100**	**40**	**60**	**860**

Legends:

Course Category: Programme Core Courses (PCC), Programme Elective Courses (PEC), Stream Specific Diversified Courses (SSC), Open Elective Courses (OEC), Project (PD), Dissertation (PD), Pedagogy Courses (PC), NEP Courses (NEP)

Stream Specific Diversified Course- 2: Advanced Semiconductor Packaging (VMEL12)/ Embedded Systems and IoT (VMEL13)/ Nano Electronics (VMEL14)
Stream Specific Diversified Course- 3: Materials for Semiconductor Packaging (VMEL15)/ ASIC Design (VMEL16)/ Flexible Electronics (VMEL17)

* All the Stream Specific Diversified Courses (SSC) have to be chosen from any one basket only. (Out of the 2/3/4 basket identified) Each basket will have 2 to 3 courses.

Offline Spell - 4

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
PD03	PD	**Dissertation Part - II**	-	-	105	375	480	16	-	-	500	300	-	-	800
Total			**-**	**-**	**105**	**375**	**480**	**16**	**-**	**-**	**500**	**300**	**-**	**-**	**800**

Legends:

Course Category: Programme Core Courses (PCC), Programme Elective Courses (PEC), Stream Specific Diversified Courses (SSC), Open Elective Courses (OEC), Project (PD), Dissertation (PD), Pedagogy Courses (PC), NEP Courses (NEP)

Online Spell –2

The online spell -2 will be offered parallelly with offline spell -3 and offline spell -4 in Second Year

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)							
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		Total Marks (TA+TWA+LA)
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
PC03	PC	**MOOC Creation**	30	-	-	30	60	02	20	30	50	-	-	-	100
PC04	PC	**Learner Centric Instructional Methods**	30	-	-	30	60	02	30	50	20	-	-	-	100
NEP07	NEP	**Intellectual Property Rights (IPR)**	15	-	-	15	30	01	25	-	25	-	-	-	50
Total			**75**	**-**	**-**	**75**	**150**	**05**	**75**	**80**	**95**	**-**	**-**	**-**	**250**

Legends:

Course Category: Programme Core Courses (PCC), Programme Elective Courses (PEC), Stream Specific Diversified Courses (SSC), Open Elective Courses (OEC), Project (PD), Dissertation (PD), Pedagogy Courses (PC), NEP Courses (NEP)

Course Curriculum Detailing- Offline Spell -1

A)	**Course Title:** Physics of Semiconductor Devices	Deemed to be University under Distinct Category
B)	**Course Code:** VMEL01	
C)	**Pre- requisite (s):**	

D) **Rationale:** Semiconductor devices are the building blocks of modern electronics. Understanding their underlying physics is crucial for comprehending how these devices function and how to design them for specific applications. It enables the optimization of device performance like efficiency, speed, reliability, and functionality and help to understand semiconductor properties of materials like silicon, gallium arsenide, and indium phosphide during fabrication techniques used in manufacture semiconductor devices. This course introduces the students to the physics of semiconductors and the inner working of semiconductor devices. It covers band structures of different materials, carrier transport mechanisms and their effects, different semiconductor devices and technologies, and integrates modern AI/ML approaches to semiconductor design and analysis. The course also acknowledges historical contributions to materials science, including relevant aspects from Indian Knowledge Systems.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following industry expected course outcomes by the learners.

Course Outcomes (COs)	Course Outcome Statements
VMEL01.CO1	Analyze Band structures of different materials, carrier transport mechanisms and their effects.
VMEL01.CO2	Design circuit with proper utilization of semiconductor p-n diodes and Schottky barrier diodes to achieve specific functionality.
VMEL01.CO3	Design BJT-based circuits for specific application.
VMEL01.CO4	Integrate MOSFETs into larger electronic systems and circuits effectively.
VMEL01.CO5	Predict the behavior of different optoelectronic devices.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)			
	PO-1 An ability to independently carry out research /investigation and development work to solve practical problems.	**PO-2** An ability to write and present a substantial technical report/document.	**PO-3** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program	**PO-4** Develop semiconductor package using design tools
VMEL01.CO1	3	2	3	2
VMEL01.CO2	3	2	3	2
VMEL01.CO3	3	2	3	2
VMEL01.CO4	3	2	3	2
VMEL01.CO5	3	2	3	2

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
VMEL01	PCC	Physics of Semiconductor Devices	30	15	-	45	90	03	30	70	20	-	-	-	120

H) Course Curriculum Detailing: For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP 2020, unique features like green skills, multidisciplinary aspects, societal connect, IKS, renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Explain band structure of semiconductor on the basis of its electrical, optical, and functional properties. *TSO 1b.* Describe behavior of carriers and the operation of devices under bias condition using fermi levels concept. *TSO 1c.* Elaborate the application of AI/ML techniques in modern semiconductor material analysis.	**Unit-1.0 Semiconductor** **1.1 Electronics in Semiconductor:** • Introduction, band structure of semiconductors, holes in semiconductors • Band structures of some semiconductors like (Si, Ge, GaAs) • Mobile carriers, doping, carriers in doped semiconductors • Historical perspective: Evolution of semiconductor materials and ancient Indian contribution to materials science through Rasa shastra principles **1.2 Carrier dynamics in Semiconductor:** • Introduction, scattering in semiconductors • Velocity electric field relations in semiconductors, very high field transport • Carrier transport by diffusion, charge injection and quasi Fermi levels • Carrier generation and recombination, continuity equation **1.3 AI/ML in Semiconductor Material Science** • Machine learning techniques for bandgap prediction and material property estimation • Data-driven approaches to semiconductor material discovery and optimization	**CO1**
TSO 2a. Explain with suitable diagram the Carrier distribution and field profile at a p-n junction. *TSO 2b.* Compare Operation of p-n junction diode under different bias conditions. *TSO 2c.* Estimate diode I-V characteristics and non-idealities. *TSO 2d.* Analyse behavior of the diode by using small signal equivalent model of diode. *TSO 2e.* Compare semiconductor junctions with metals and insulators. *TSO 2f.* Illustrate computational intelligence for semiconductor junction analysis.	**Unit-2.0 Semiconductor Junction** 2.1 **P-N Junction Diodes:** • Device demands, unbiased p-n junction, p-n junction under bias • Real diode, high voltage effects in diodes • Modulation and switching ac response • Traditional Indian approaches to material junctions and interfaces (from ancient metallurgy) 2.2 **Metal and Insulator Junctions:** • Metals as conductors, Schottky barrier diode • Ohmic contacts, insulator-semiconductor junction. 2.3 **Computational Intelligence in Junction Analysis:** • Machine learning algorithms for diode characterization and parameter extraction 2.4 AI models for predicting junction behaviour under extreme conditions	**CO2**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 3a. Explain working principle of BJT. *TSO 3b.* Distinguish different modes of operation of BJT. *TSO 3c.* Estimate Static performance parameters of BJP. *TSO 3d.* Explain AI/ML applications in BJT technology.	**Unit-3.0 Bipolar Junction Transistor** **3.1 BJT Structure and Operation:** • Introduction, Bipolar transistor structure and fundamental operation • Static characteristics of bipolar transistors • BJT static performance parameters, secondary effects in real devices • A charge control analysis, bipolar transistor as an inverter • High frequency behaviour of BJT **3.2 Bipolar transistors: A Technology roadmap** • Historical development and evolution • Modern applications and emerging trends • Indigenous development perspectives in transistor technology **3.3 AI/ML Applications in BJT Technology:** • Machine learning for BJT parameter extraction from measurement data • AI-driven BJT fault diagnosis and lifetime prediction	**CO3**
TSO 4a. Interpret C-V characteristics of MOS capacitor. *TSO 4b.* Explain the physical structure and detailed operation of MOSFETs. *TSO 4c.* Find the terminal I-V characteristics of MOSFETs and their associated non-idealities. *TSO 4d.* Write AI/ML techniques used to MOSFET design and analysis.	**Unit-4.0 Field Effect Transistor (MOSFET)** 4.1 **MOSFET Structure and Operation:** • Introduction, MOSFET structure and fabrication • Metal-oxide semiconductor capacitor • Capacitance voltage characteristics of the MOS structure • Metal oxide semiconductor field effect transistor • Important issues in real MOSFETs 4.2 **AI/ML in MOSFET Design and Optimization:** • Machine learning techniques for MOSFET parameter extraction. • Reinforcement learning for process parameter optimization 4.3 Knowledge integration from ancient Indian metallurgical practices in modern fabrication approaches	**CO4**
TSO 5a. Categorize various FETs on the basis of its structure and operation. *TSO 5b.* Compare working of JFET and MESFET. *TSO 5c.* Differentiate between JFET and MESFET Effects. *TSO 5d.* Illuminate high frequency, high speed issues JFET and MESFET.	**Unit-5.0 JFET, MESFET and Semiconductor Optoelectronics** 5.1 **JFET and MESFET:** • Introduction, JFET, MESFET structure and operation • Current-voltage characteristics	**CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 5e. Describe physical operation of devices like LEDs, lasers and light detectors. *TSO 5f.* Write AI/ML techniques used in optoelectronic device design and analysis.	• Effects in real devices • High frequency high speed issues 5.2 **Semiconductor Optoelectronics:** • Introduction, optical absorption in a semiconductor • Photo current in a p-n diode, P-I-N photodetector • Light emission, semiconductor laser-basic principles • Ancient Indian optical knowledge systems and their relation to modern optoelectronics 5.3 **AI/ML in Optoelectronic Devices:** • Machine learning in photocurrent prediction and optimization • AI algorithms for optimizing semiconductor laser design	

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

- Investigate how temperature affects the mobility and performance (conductivity, carrier concentration) of different semiconductor materials (e.g., Silicon, Gallium Arsenide).
- Investigate the correlation between ancient Indian metallic alloy preparation techniques and modern semiconductor doping strategies.
- Develop machine learning models to predict semiconductor device reliability based on electrical characteristics.

Note: Depending on the requirement of each laboratory experience, micro project and research-based problems, the performance may be conducted in online/offline mode and accordingly appropriate assessment tools may be used.

L) Suggested Term Work (TW):

a. Assignment(s):

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

- Explain the MOSFET structure, operation, its types and its application.
- Elaborate mode of operation of BJT with application of each mode.

b. Seminar Topics:

- Diffusion
- BJT as Inverter
- MOSFETs
- PIN photodetector

M) Suggested Specification Table for End Semester Theory Assessment (ETA): Questions may be designed based on the higher taxonomy level of cognitive domain.

COs	Relevant Unit Number and Title	Marks
CO1	Unit-1.0 Semiconductor	14
CO2	Unit-2.0 Semiconductor Junction	12
CO3	Unit-3.0 Bipolar Junction Transistor	12
CO4	Unit-4.0 Field Effect Transistor (MOSFET)	16
CO5	Unit-5.0 JFET, MESFET and Semiconductor Optoelectronics	16
Total		**70**

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. 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. To ensure learning, research-based problems may be designed and implemented.

O) Major Equipment, Tools and Software for Laboratory and Research Work: (Not Applicable)

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Physics of Semiconductor Devices	S.M. Sze, Kwok K. Ng	Wiley; Third edition (1 January 2008) ISBN-13 : 978-8126517022
2.	Semiconductor Devices, Basic Principles, Wiley Student Edition, 2012	Jasprit Singh,	Wiley Student Edition, 2012 ISBN-13 : 978-0471362456

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
3.	Solid State Electronic Devices	Ben G. Streetman	Prentice Hall India, 2013. ISBN-13 : 978-8120330207
4.	Fundamentals of Modern VLSI Devices,	Yuan Taur, Tak.H.Ning	Cambridge University Press, 2011. ISBN-13 : 978-1316649794
5.	Semiconductors Physics and Devices,	Donald Neamen,	Tata McGraw Hill, 2011. ISBN-13 : 978-0071070102
6.	Introduction to Semiconductor Materials and Devices,	Tyagi M.S.	Wiley Publications, 2010. ISBN-13 : 978-8126518678

b) Online Educational Resources (OER):

1) https://archive.nptel.ac.in/courses/108/108/108108122/#
2) https://onlinecourses.nptel.ac.in/noc21_ee80/preview
3) https://user.eng.umd.edu/~neil/enee704/Goldsman_Darmody_Intro_QM_Dev_Phys.pdf
4) https://onlinelibrary.wiley.com/doi/book/10.1002/0470068329
5) https://www2.mvcc.edu/users/faculty/jfiore/Linear/SemiconductorDevices.pdf
6) http://vlabs.iitkgp.ac.in/ssd/index.html
7) https://vlab.amrita.edu/?sub=1&brch=282

Q) Course Curriculum Developer

S. No.	Name	E-mail Address
1.	Prof. Sanjeet Kumar	skumar@nitttrbpl.ac.in

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A)	**Course Title:** IC fabrication Technology	Deemed to be University under Distinct Category
B)	**Course Code:** VMEL02	
C)	**Pre- requisite (s):** Fundamentals of Physics, Material Science, Introduction to Machine Learning, Basic Programming (Python/MATLAB)	

D) **Rationale:** The fabrication of integrated circuits is fundamental to all modern electronic devices. A deep knowledge of this process is crucial for engineers and researchers who aim to contribute to advancements in electronics. IC technology evolves new fabrication techniques integrated with AI/ML algorithms are continually being developed for yield optimization, quality control, and autonomous manufacturing. Machine learning models are now essential for predicting process outcomes, optimizing parameters in real-time, and enabling predictive maintenance of fabrication equipment. The principles and techniques of AI-enhanced IC fabrication have applications beyond traditional electronics, impacting fields such as nanotechnology, photonics, and bioelectronics through intelligent process control and automated design optimization. AI-driven fabrication processes enable the development of next-generation devices with improved performance and reduced manufacturing costs. The semiconductor industry increasingly demands professionals skilled in both traditional fabrication processes and modern AI/ML applications for smart manufacturing, process optimization, and quality assurance. Knowledge of AI-enhanced fabrication processes significantly enhances employability in high-tech industries pursuing digital transformation. This course prepares students for advanced research roles in academia and industry.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following industry expected course outcomes by the learners.

Course Outcomes (COs)	Course Outcome Statements
VMEL02.CO1	Critically examine the sequence of processes and advanced technologies involved in IC fabrication, with a focus on leveraging AI/ML techniques for process control, defect detection, and yield improvement.
VMEL02.CO2	Interpret the theoretical principles underlying IC fabrication, including materials science, electronic properties, and microfabrication techniques.
VMEL02.CO3	Prepare photolithography masks using traditional methods and AI-assisted design optimization techniques.
VMEL02.CO4	Apply ML algorithms to predict and optimize impurity selection and doping profiles for achieving desired electrical characteristics in semiconductor devices.
VMEL02.CO5	Equip students with practical skills empowered by AI/ML tools for smart manufacturing and predictive analytics for IC fabrication techniques.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)			
	PO-1 An ability to independently carry out research /investigation and development work to solve practical problems.	**PO-2** An ability to write and present a substantial technical report/document.	**PO-3** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program	**PO-4** Develop semiconductor package using design tools
VMEL02.CO1	3	2	2	2
VMEL02.CO2	3	2	2	2
VMEL02.CO3	3	2	2	2
VMEL02.CO4	3	2	3	2
VMEL02.CO5	3	2	2	2

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
VMEL02	PCC	IC Fabrication Technology	45	15	45	15	120	04	30	70	20	-	30	20	170

H) Course Curriculum Detailing: For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP 2020, unique features like green skills, multidisciplinary aspects, societal connect, IKS, renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Summarize the IC fabrication process with suitable sketches. *TSO 1b.* Describe the clean room concept in detail. *TSO 1c.* Critically analyze the IC fabrication trends. *TSO 1d.* Classify the types of components to be fabricated in the batch process. *TSO 1e.* Summarize IC fabrication processes with AI/ML enhancement opportunities. *TSO 1f.* Analyze how machine learning improves manufacturing. efficiency. *TSO 1g.* Evaluate AI applications in smart fab environments. *TSO 1h.* Describe clean room concepts, including automated monitoring systems.	**Unit-1.0 Introduction to IC Fabrication**: Overview of the integrated circuit fabrication process, Historical development and evolution of IC fabrication technology, Importance of clean room and clean room concept, Emerging Trends and Future directions: - Overview of current trends in IC fabrication (e.g., 3D integration, heterogeneous integration), Future challenges and opportunities in the field, ingot, wafer, components, and types of ICs. sustainable semiconductor materials their properties and use for IC fabrications. Introduction to AI/ML in semiconductor manufacturing Smart manufacturing concepts and Industry 4.0 in fab facilities Machine learning applications for yield optimization	**CO1**
TSO2a. Describe the crystal growth process in detail giving importance to the parameter selection and material in use. *TSO2b.* Explain the need for Cleanroom in IC fabrication processes specific to wafer preparation. *TSO2c.* Classify semiconductor materials based on their chemical and physical properties. *TSO2d.* Describe the wafer slicing procedure and its types in detail. *TSO2e.* Describe crystal growth processes and ML-based quality prediction. *TSO2f.* Explain cleanroom importance including AI-powered monitoring.	**Unit-2.0 Crystal Growth and Wafer Preparation:** Crystal structures and properties, Crystal growth techniques (e.g., Czochralski method), Wafer slicing and polishing Cleanroom Environment:- Importance of cleanroom environment in IC fabrication, Cleanroom design and maintenance, Cleanroom protocols and procedures, Sustainable materials for IC fabrications, impurity materials and different types of semiconductor materials and their properties, Machine learning for crystal quality prediction, Computer vision for wafer defect detection, Statistical process control using ML algorithms	**CO2**
TSO 3a. Describe the principle of Photolithography in detail and explain how it is useful in IC fabrication. *TSO 3b.* Critically analyze wet and dry etching techniques with suitable application. *TSO 3c.* Describe the step-by-step procedure of the PVD and CVD process. *TSO 3d.* Compare various types of lithography procedures. *TSO 3e.* Describe photolithography principles and AI optimisation techniques.	**Unit-3.0 Photolithography and etching: -** Principles of photolithography, Photoresist coating and exposure, Mask alignment and patterning, Photomask fabrication, Etching and Pattern Transfer:- Wet and dry etching techniques, Plasma etching, Selective etching processes, Pattern transfer methods, Deposition Processes:- Physical vapor deposition (PVD), Chemical vapor deposition (CVD), Atomic layer deposition (ALD), Electrochemical deposition (electroplating), Lithography and Patterning:- Advanced lithography techniques (e.g., EUV	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 3f. Design ML models for etch process prediction. *TSO 3g.* Compare lithography procedures including AI-assisted methods.	lithography), Patterning of features at nanoscale, Resolution enhancement techniques, Machine learning for lithography process optimization , AI-assisted mask design and layout optimization, Predictive models for etch rate and selectivity	
TSO 4a. Describe Ion implantation procedure in detail. *TSO 4b.* Explain the Doping procedure considering the specific type of impurity. *TSO 4c.* Why Isolation is provided in the IC fabrication procedure? explain with a suitable example. *TSO 4d.* Differentiate between Ion implantation and Doping procedure. *TSO 4e.* Describe the metallization procedure in detail. *TSO 4f.* Describe ion implantation with ML-based parameter optimization. *TSO 4g.* Predict doping profiles using machine learning models. *TSO 4h.* Implement AI for metallization process control. *TSO 4i.* Differentiate traditional and AI-enhanced doping procedures.	**Unit-4. Ion Implantation and Doping** Ion Implantation and Doping: - Introduction to ion implantation, Doping processes for introducing impurities, Annealing techniques for activating dopants, Device Isolation and Interconnection: - Techniques for isolating individual devices on a chip, Interconnection schemes (e.g., metallization layers), Planarization processes (e.g., chemical mechanical polishing) **Machine learning for doping profile prediction, AI-optimized ion implantation parameters**	**CO4**
TSO 5a. Explain the need for packaging of various size and types of ICs. *TSO 5b.* Compare different types of IC packages. *TSO 5c.* Describe the IC packaging design rules with proper examples. *TSO 5d.* Describe the testing procedure of ICs. *TSO 5e.* With a proper flow chart describe the step-by-step IC packaging procedure. *TSO 5f.* Explain packaging needs with AI-optimized design approaches. *TSO 5g.* Describe testing procedures, including AI-enhanced methodologies.	**Unit-5.0 Packaging and Testing and tools for Designing**: - Packaging and Testing: - Overview of IC packaging methods, testing methodologies for ICs, Reliability and quality assurance in IC manufacturing, and design test in IC fabrication technology, Methods for packaging integrated circuits, along with testing procedures to verify performance, Types of packaging, packaging materials, and design rules, **Machine learning for test pattern generation, AI-driven packaging optimization**	**CO5**

J) Suggested Laboratory Experiences:

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
LSO 1.1 Use standard cleanroom procedures with AI-based monitoring systems *LSO 1.2* Follow the safety procedures	1.	Standard Cleanroom Procedures	CO5
LSO 2.1 Follow the standard steps and procedure for IC testing.	2.	Test IC and Components functionality and performance	CO5
LSO 3.1 Develop skills for preparing wafers for various types of packaging	3.	Packaging procedures	CO5
LSO 4.1. Photolithography mask design preparation *LSO 4.2.* Create photolithography masks using AI-assisted design tools	4.	Prepare photolithography masks for the various types of device fabrications using AI assisted design tool.	C03
LSO 5.1. EDA tools for the IC fabrication	5.	Develop simulation using EDA tools Use EDA tools for the final fabrication of components on the wafer.	CO5
LSO 6.1. Use proper types of impurities for the fabrication of the specific device *LSO 6.2.* Packaging of the single components.	6.	EDA tools for IC fabrication	CO5

K) Suggested Research Based Problems

i. Investigate deep learning applications in extreme ultraviolet (EUV) lithography process optimization.
ii. Research reinforcement learning algorithms for autonomous defect detection and classification.
iii. Develop AI-enhanced metrology techniques using computer vision and neural networks.
iv. Novel inspection technique to detect nanoscale defects in advanced nodes.
v. Reliability Challenges in IC Fabrication for Automotive Applications.

Note: Depending on the requirement of each laboratory experience, micro project and research-based problems, the performance may be conducted in online/offline mode and accordingly appropriate assessment tools may be used.

L) Suggested Term Work (TW):

a. Assignment(s):

- Critically analyse lithography processes and develop ML models for process optimization.
- Create a comparative study of traditional vs. AI-enhanced thermal stability analysis.
- Design a neural network for predicting semiconductor material properties.

b. Micro Projects: - (Sample Title/statements)

- Prepare a report on the cleanroom design and another requirement.
- Develop an AI-powered cleanroom monitoring system design.
- Create a machine learning model for predicting fabrication yield.
- Design a computer vision system for automated wafer inspection.

c. Visits:

Visit an IC fabrication setup and prepare a detailed report on the infrastructure requirements for future setups.

d. Self- Learning Topics:

- Characteristics of semiconductors.
- Band Structure of Si, Ge and GaAs and other semiconductor materials.
- The best deposition techniques for achieving uniform and high-quality 2D material layers.
- Integration of 2D materials improves the performance of next-generation transistors.
- Machine learning algorithms for process optimisation.
- Computer vision applications in semiconductor manufacturing.
- Statistical process control using AI/ML technique

M) Suggested Specification Table for End Semester Theory Assessment (ETA): Questions may be designed based on the higher taxonomy level of cognitive domain.

COs	Relevant Unit Number and Title	Marks
CO1	Unit-1.0: Introduction to IC Fabrication	13
CO2	Unit-2.0: Crystal Growth and Wafer Preparation	13
CO3	Unit-3.0: Photolithography and Etching	16
CO4	Unit-4.0: Ion Implantation and Doping	14
CO5	Unit-5.0: Packaging and Testing and Tools for Designing	14
Total		**70**

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. 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. To ensure learning, research-based problems may be designed and implemented.

O) Major Equipment, Tools and Software for Laboratory and Research Work:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience /Practical Number
1.	High-Performance Computing System	GPU-enabled workstations for ML training	ALL AI/ML Labs
2.	Clean room facility	**Cleanroom Class:** ISO 5 to ISO 7 **HVAC System:** High-efficiency particulate air (HEPA) filters. **Cleanroom Apparel:** Gowns, gloves, masks, and shoe covers. **Antistatic Workstations:** For handling sensitive semiconductor materials.	All
3.	Fabrication infrastructure	Lithography Equipment, Mask Aligner, CVD system, dopping system, metallization system, basic packaging system, etching and cleaning equipment, wafer handling and preparation tools, and other facility for the fabrication	All
4.	Enhanced TCAD Suite	Process and Device simulation, Mixed mode simulation, educational and research licence, **Synopsys with ML integration capabilities**	All AI/ ML Labs
5.	AI/ML Software Suite	Python, TensorFlow, PyTorch, scikit-learn	ALL AI/ML Labs
6.	Data Analytics Platform	Real-time process data analysis tools	Process Optimization

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Principles of Semiconductor Devices	Sima Dimitrijev	Oxford University Press., 1st Edition (2006)
2.	Introduction to Microelectronic	Fabrication, Richard C. Jaeger,	Prentice Hall,2nd Edition (2001)
3.	Microchip Fabrication: A Practical Guide to Semiconductor Processing,	Peter Van Zant,)	McGraw-Hill Education, Edition: 5th Edition (2018
4.	Fundamentals of Semiconductor Fabrication,	Gary S. May and Simon M. Sze,	Wiley, Edition: 1st Edition (2003)
5.	Semiconductor Manufacturing Handbook	Hwaiyu Geng	McGraw-Hill Education,2nd Edition (2005)
6.	Machine Learning for Semiconductor Manufacturing	Various Authors	IEEE Press, Latest Edition
7.	AI in Manufacturing: Deep Learning Applications	Industry Authors	Springer, Recent Edition
8.	Computer Vision for Quality Control	Technical Authors	Academic Press

b) Online Educational Resources (OER):

1) https://archive.nptel.ac.in/courses/108/108/108108122/#
2) https://onlinecourses.nptel.ac.in/noc21_ee80/preview
3) https://user.eng.umd.edu/~neil/enee704/Goldsman_Darmody_Intro_QM_Dev_Phys.pdf
4) https://onlinelibrary.wiley.com/doi/book/10.1002/0470068329
5) https://www2.mvcc.edu/users/faculty/jfiore/Linear/SemiconductorDevices.pdf
6) http://vlabs.iitkgp.ac.in/ssd/index.html
7) https://vlab.amrita.edu/?sub=1&brch=282
8) MIT Open Course Ware: Machine Learning for Engineers
9) Stanford CS229: Machine Learning Course
10) Coursera: AI for Manufacturing Specialization
11) edX: Computer Vision Fundamentals
12) Industry 4.0 and Smart Manufacturing MOOCs
13) Traditional semiconductor fabrication resources (existing links)

Q) Course Curriculum Developer

S. No.	Name	E-mail Address
1.	Prof. Anjali Potnis	apotnis@nitttrbpl.ac.in

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A)	**Course Title:** Digital CMOS IC Design	Deemed to be University under Distinct Category
B)	**Course Code:** VMEL03	
C)	**Pre- requisite (s):**	

D) **Rationale:** This course is essential for understanding the foundational principles and practical applications of CMOS technology in digital circuit design. It equips students with the skills needed to design, simulate, and optimize complex integrated circuits, which are crucial for careers in electronics and semiconductor industries. Studying the five units provides a comprehensive understanding of CMOS circuit design and its applications. The increasing complexity of digital CMOS integrated circuit (IC) design demands innovative, intelligent solutions beyond traditional methods. Artificial Intelligence (AI), including machine learning and deep learning, offers powerful tools to automate and optimize critical design stages such as logic synthesis, placement, routing, defect detection, and performance prediction. This course aims to equip students with interdisciplinary skills by combining fundamental CMOS digital design principles with AI techniques, preparing them to tackle challenges in modern semiconductor industries and research. By integrating AI into the design flow, students will learn to accelerate development cycles, enhance circuit performance, and contribute to next-generation EDA innovations.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following industry expected course outcomes by the learners.

Course Outcomes (COs)	Course Outcome Statements
VMEL03.CO1	Analyze the performance of CMOS based Circuits.
VMEL03.CO2	Analyze the performance of CMOS based logic gates.
VMEL03.CO3	Design combinational & sequential MOS logic circuits.
VMEL03.CO4	Analyze the performance of CMOS Dynamic Logic Circuits
VMEL03.CO5	Design low power circuits for the given application.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)			
	PO-1 An ability to independently carry out research /investigation and development work to solve practical problems.	**PO-2** An ability to write and present a substantial technical report/document.	**PO-3** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program	**PO-4** Develop semiconductor package using design tools
VMEL03.CO1	3	2	2	2
VMEL03.CO2	2	-	3	3
VMEL03.CO3	2	2	2	3
VMEL03.CO4	3	3	3	3
VMEL03.CO5	3	3	3	3

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		Total Marks (TA+TWA+LA)
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
VMEL03	PCC	Digital CMOS IC Design	45	15	45	15	120	04	30	70	20	-	20	30	170

H) Course Curriculum Detailing: For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP 2020, unique features like green skills, multidisciplinary aspects, societal connect, IKS, renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Analyse CMOS logic gate configurations *TSO 1b.* Design CMOS inverters to meet specified performance criteria. *TSO 1c.* Describe machine learning technique to improve inverter performance *TSO 1d.* Design transmission gate circuits *TSO 1e.* Analyse the impact of interconnect parasites on circuit performance.	**Unit-1.0 Introduction to CMOS Circuits** 1.1 CMOS Logic 1.2 MOS Inverter, CMOS Inverters 1.3 Transmission Gate, AI Accelerators, Noise margin optimization using AI algo. 1.4 MOS Inverter's Switching Characteristics & Interconnect Effects: Delay Time, Interconnect Parasitic, Capacitances (Gate & routing capacitance), Resistance.	**CO1**
TSO 2a. Estimate delay across various components *TSO 2b.* Describe the procedure to apply delay optimization techniques in logic gates. *TSO 2c.* Calculate optimal stage ratios for minimum delay propagation. *TSO 2d.* Analyse power consumption in different circuit configurations *TSO 2e.* Analyse BiCMOS circuit performance characteristics	**Unit-2.0 Logic Gates & Delays** 2.1 RC Delay, Wire Delays, Inductances, Gate Delays, Delay optimization strategies. 2.2 Stage Ratio, Power Dissipation. 2.3 CMOS Logic Gate Design. 2.4 Transmission Gate. 2.5 BiCMOS circuits.	**CO2**
TSO 3a. Design efficient NAND and NOR gates with optimal sizing. *TSO 3b.* Describe AI algorithm for logic synthesis and circuit optimization. *TSO 3c.* Analyse power consumption during switching transitions. *TSO 3d.* Design bistable circuits including latches and flip-flops *TSO 3e.* Analyse timing requirements and constraints for clocked circuits.	**Unit-3.0 Combinational & Sequential Logic Circuits** 3.1 Combinational Circuits Design: NAND Gate, NOR Gate, AI methods for logic synthesis and fault detection in CMOS designs 3.2 Transient Analysis of NAND & NOR gates, 3.3 Sequential MOS Logic Circuits, Behavior of Bistable element, pass transistor logic 3.4 CMOS Latches & Clocked Flip-flop, 3.5 Clock Skew, Clocking Strategies.	**CO3**
TSO 4a. Analyse CMOS fabrication processes. *TSO 4b.* Design physical layouts following standard CMOS design rules. *TSO 4c.* Describe AI-driven layout optimization tools to optimize circuit performance *TSO 4d.* Design CMOS dynamic logic circuits *TSO 4e.* Implement the given dynamic circuits using CAD tool.	**Unit-4.0 CMOS Technology & Dynamic Logic Circuits** 4.1 CMOS Technology, n-well, p-well process, CMOS process enhancement. 4.2 Interconnect and circuit elements, Layout design rules, Latch up, AI-driven layout optimization tools. 4.3 CMOS Dynamic Logic Circuit: Transfer, Charge storage and Leakage, Voltage Bootstrapping, AI algorithms for detecting leakage patterns and predicting charge loss in dynamic nodes under various operating conditions. 4.4 High performance dynamic CMOS circuits: Domino CMOS logic, NORA CMOS logic, zipper CMOS circuits, TSPC dynamic CMOS.	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 5a. Design various memory architectures using MOS technology. *TSO 5b.* Describe AI/ML to optimize memory layout for speed and power *TSO 5c.* Analyze comprehensive power consumption models. *TSO 5d.* Design low power circuits through Voltage estimation *TSO 5e.* Design adiabatic logic Circuits	**Unit-5.0 Semiconductor Memories and Low Power circuits** 5.1 Semiconductor Memories: ROM, DRAM, SRAM, PLA, Cell, Leakage. Circuit and Input/Output Circuit, AI/ML to optimize memory layout for speed and power 5.2 Low power circuits: overview of power consumption, low power design through Voltage estimation and optimization of switching activity, AI techniques to estimate power consumption at early design stages 5.3 Reduction of switched capacitor, 5.4 Adiabatic logic circuits.	**CO5**

J) Suggested Laboratory Experiences:

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
LSO 1.1 Simulate using Cadence design tool/LT Spice.	1.	Installation of EDA Tool i.e. Cadence Tool	CO1
LSO 2.2 Test the performance of the given NMOS and PMOS	2.	Performance of NMOS and PMOS	CO1
LSO 3.2 Analyse DC & Transient behaviour of CMOS Inverter	3.	DC and Transient analysis of CMOS Inverter.	CO1
LSO 4.1 Analyse the effects of channel length modulation on CMOS Inverter.	4.	Effect of Channel length variation on I/O Characteristics of CMOS Inverter	C01
LSO 5.2. Analyse universal gates' behaviour.	5.	Transient analysis of NAND, NOR Gate.	CO2
LSO 6.1. Analyse basic gates' behaviour	6.	Transient analysis of AND, OR Gate.	CO2
LSO 7.1. Analyse flip-flops' behaviour	7.	Transient Analysis of Latch and Flip flop.	CO3
LSO 8.1 Analysis of Resistive Load Inverter Characteristics enter.	8.	DC and Transient analysis of resistive load Inv	CO1
LSO 9.1 Analysis of BUFFER Circuit.	9.	DC and Transient analysis of buffer circuit	CO3

K) Suggested Research Based Problems:

i. Can AI models (like deep reinforcement learning) automatically generate optimal low-power designs, minimizing both dynamic and leakage power?

ii. Can you train a machine learning model to predict critical parameters like delay, power, and area for digital CMOS cells directly from design parameters, speeding up the design process?

iii. Low Power Design Techniques in CMOS Circuits:
- Research on innovative techniques for reducing power consumption in CMOS circuits, focusing on dynamic and static power reduction methods. Investigate methods like power gating, dynamic voltage scaling, clock gating, and multi-threshold CMOS (MTCMOS) to optimize power efficiency in modern ICs. The research could explore the trade-offs between power, performance, and area.

iv. Design and Optimization of FinFET-Based Digital Circuits:
- FinFET technology is a promising solution for scaling CMOS beyond traditional planar structures. Explore the design and optimization of digital circuits using FinFET technology to improve performance and leakage power. Study FinFET-based gate design, circuit optimization, and its impact on timing, area, and power compared to planar CMOS.

v. Design of High-Speed and Energy-Efficient CMOS Adders or Multipliers:
- High-speed adders and multipliers are critical components of digital systems. Research different architectures for CMOS adder/multiplier designs such as carry-lookahead, carry-skip, and parallel-prefix adders, focusing on optimizing the speed-power-area trade-off. Use emerging technologies like approximate computing to further enhance energy efficiency for specific applications.

vi. Design of SRAM Cells for Low Voltage and Ultra-Low Power Applications:
- Research on 6T, 8T, and 10T SRAM cell designs focusing on optimizing stability, write/read performance, and leakage power in sub-threshold and near-threshold regimes. Study the effects of voltage scaling on SRAM stability and performance, and develop new SRAM architectures for low-power IoT and edge devices.

vii. Radiation-Hardened CMOS Circuit Design for Space Applications:
- Investigate radiation-hardened CMOS circuits that can withstand the harsh environment of space. Research techniques like triple-modular redundancy (TMR), hardened-by-design (HBD) approaches, and the use of special gate designs to minimize the impact of single-event upsets (SEUs) and total ionizing dose (TID) on circuit reliability.

viii. Machine Learning-Assisted CMOS IC Design:
- Research the application of machine learning (ML) techniques in the design and optimization of CMOS ICs. Explore how ML algorithms can be used for tasks like sizing transistors, predicting performance metrics, or optimizing power and area. Develop tools that integrate ML-based decision-making in various stages of CMOS design flows.

Note: Depending on the requirement of each laboratory experience, micro project and research-based problems, the performance may be conducted in online/offline mode and accordingly appropriate assessment tools may be used.

L.) Suggested Term Work (TW):

a. Assignment (s):

- Explore how Artificial Intelligence (AI) methods can improve or automate various stages of digital CMOS IC design — from logic synthesis to layout generation — and propose innovative solutions.
- Design a 1-bit full adder using CMOS technology. Provide the schematic diagram and explain the working principle of the full adder. How would you extend this design to create a 4-bit adder?
- Design the basic logic gates (AND, OR, NOT, XOR) using CMOS technology. Provide the schematic diagrams and describe the operation of each gate.
- Integrate the designed 4-bit adder and the logic gates to form a 4-bit ALU. Describe the control logic required to select between different arithmetic and logic operations. Provide a block diagram of the integrated ALU.

b. Micro Projects: - (Sample Title/statements)

- Delay Prediction of CMOS Inverter using Machine Learning
- Prepare a report on the low power VLSI techniques based on literature survey of last 10 years and submit it.
- Design a 4-bit CMOS based ALU for basic function i.e. Addition, Subtraction, Multiplication, Division
- Design and optimization of CMOS Inverter
- Design and Simulation of a 4-Bit Binary Counter Using CMOS Technology.

M) Suggested Specification Table for End Semester Theory Assessment (ETA): Questions may be designed based on the higher taxonomy level of cognitive domain.

COs	Relevant Unit Number and Title	Marks
CO1	Unit-1.0 Introduction to CMOS Circuits	12
CO2	Unit-2.0 Logic Gates & Delays	12
CO3	Unit-3.0 Combinational & Sequential Logic Circuits	16
CO4	Unit-4.0 CMOS Technology & Dynamic Logic Circuits	16
CO5	Unit-5.0 Semiconductor Memories and Low Power circuits	14
Total		**70**

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. 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. To ensure learning, research-based problems may be designed and implemented.

O) Major Equipment, Tools and Software for Laboratory and Research Work:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience /Practical Number
1.	Computer system	Processor Intel Core i5, 4 GB RAM, 15 GB free disk space	All
2.	CAD Software	Cadense Software Standard Bundle	All

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition withISBN
1.	CMOS Digital Integrated Circuits- Analysis and design.	Kang, Sung-Mo., & Leblebici, Yusuf	New Delhi: Tata McGraw-Hill Publication (2002)., ISBN-13: 978-0-07-2460537
2.	Principles of CMOS VLSI Design.	Weste, Neil. H. E., & Eshraghian, K	Boston: New York: Addison Wesley Publication. (1998). ISBN-13: 978-0201533767
3.	CMOS Circuit Design, Layout and Simulation.	Backer, Jacob., Harry, W. Li., & Boyce, David. E.	New Delhi: PHI Publication. (1999)., ISBN-13: 978-1119481515
4.	Basic VLSI Design.	Pucknell, Douglas. A., & Eshragian, K	New Delhi: PHI Publication. (2000)., ISBN-13: 978-0-7248-0105-3
5.	AI-Enabled Electronic Circuit and System Design: From Ideation to Utilization	Ali Iranmanesh, Hossein Sayadi	Springer, 2025, ISBN: 978-3-031-71435-1

b) Online Educational Resources (OER):

1) Computation Structures - Part 1: Digital Circuits by Chris Terman, https://www.edx.org/course/computation-structures-part-1-digital-mitx-6-004-1x-0
2) CMOS Digital VLSI Design by Prof. S. Dasgupta, https://onlinecourses.nptel.ac.in/noc19_ee25/preview

Q) Course Curriculum Developer

S. No.	Name	E-mail Address
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****

A)	**Course Title:** Semiconductor Packaging	Deemed to be University under Distinct Category
B)	**Course Code:** VMEL04	
C)	**Pre- requisite (s):** Basic Electronics	

D) **Rationale:** Teaching semiconductor packaging is crucial due to its integral role in the performance, reliability, and cost-effectiveness of electronic devices. As the bridge between the silicon chip and the final electronic product, packaging impacts thermal management, signal integrity, power distribution, and physical protection. The curriculum should encompass an overview of packaging types and technologies, materials used, design considerations, manufacturing processes, and the latest advancements such as 3D packaging and system-in-package (SiP). Emphasizing real-world applications, industry standards, and future trends prepares students to innovate in the rapidly evolving field of electronics. Semiconductor packaging with AI integration enhances reliability, yield, and performance by enabling intelligent defect detection, predictive maintenance, and process optimization. AI-driven analytics empower real-time decision-making, crucial for managing complex, miniaturized, and high-density packaging technologies.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following industry expected course outcomes by the learners.

Course Outcomes (COs)	Course Outcome Statements
VMEL04.CO1	Apply design techniques to improve reliability of Semiconductor Packages
VMEL04.CO2	Evaluate materials for housing and encapsulating the semiconductor device
VMEL04.CO3	Analyze inspection data to assess wafer quality
VMEL04.CO4	Evaluate the performance of conventional packaging techniques
VMEL04.CO5	Implement given encapsulation technique for Semiconductor Package

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)			
	PO-1 An ability to independently carry out research /investigation and development work to solve practical problems.	**PO-2** An ability to write and present a substantial technical report/document.	**PO-3** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program	**PO-4** Develop semiconductor package using design tools
VMEL04.CO1	3	-	3	3
VMEL04.CO2	2	2	2	-
VMEL04.CO3	3	3	3	2
VMEL04.CO4	2	2	3	2
VMEL04.CO5	3	-	2	3

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		Total Marks (TA+TWA+LA)
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
VMEL04	PEC	Semiconductor Packaging	45	15	45	15	120	04	30	70	20	-	20	30	170

H) Course Curriculum Detailing: For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP 2020, unique features like green skills, multidisciplinary aspects, societal connect, IKS, renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Identify the sources and impacts of stray components. *TSO 1b.* Describe design techniques to minimize stray components *TSO 1c.* Implement strategies for compact design using CAD tool *TSO 1d.* Apply given testing and inspection method to detect and address defects. *TSO 1e.* Perform stress testing to evaluate the reliability of semiconductor packages	**Unit-1.0: Essentials of Packaging:** 1.1 Minimizing of stray components, 1.2 Reduction of Form Factor, 1.3 Quality Control, 1.4 Reliability 1.5 Reliability prediction using AI for Semiconductor Packages	**CO1**
TSO 2a. Describe fundamental principles of floor planning *TSO 2b.* Evaluate appropriate materials for housing and encapsulating the semiconductor device *TSO 2c.* Explain design constraints and performance requirements for semiconductor packaging. *TSO 2d.* Describe optimization techniques to effectively allocate space and resources within the package	**Unit-2.0 Design Aspects of Packaging**: 2.1 Floor Planning 2.2 Layout 2.3 Housing & Packaging Plan 2.4 Process formulation 2.5 Process optimization using AI for Semiconductor Packages	**CO2**
TSO 3a. Analyze inspection data to assess wafer quality and identify trends. *TSO 3b.* Develop skills to ensure precision and accuracy in the dicing process *TSO 3c.* Apply alignment techniques to ensure proper orientation and placement of dies for subsequent packaging processes *TSO 3d.* Describe industry standards for screening semiconductor devices	**Unit-3.0 Dicing & Inspection:** 3.1 Wafer Level Inspection, 3.2 Dicing and Singulation, 3.3 Sorting & Alignment, 3.4 Screening as per standards	**CO3**
TSO 4a. Describe Chip on Board (COB) Technology *TSO 4b.* Evaluate the quality and reliability of COB assemblies through testing and failure analysis *TSO 4c.* Develop proficiency in applying dam-and-fill techniques, *TSO 4d.* Describe various types of plastic packages *TSO 4e.* Evaluate the performance of metal can packaged devices through rigorous testing	**Unit-4.0 Conventional Packaging:** 4.1 Chip on Board Technology, 4.2 Dam-& Fill Techniques, 4.3 Plastic Packaging, 4.4 Ceramic Packaging, 4.5 Metal Can Packaging 4.6 Performance prediction using AI for Semiconductor Packages	**CO4**
TSO 5a. Describe various types of bonding used in semiconductor packaging. TSO 5b. Describe ball bonding and wedge bonding methods. TSO 5c. Implement given encapsulation technique. TSO 5d. Evaluate the properties of sealing materials. *TSO 5e.* Implement quality assurance measures to ensure efficient markings on semiconductor packages.	**Unit-5.0 Customized Packaging:** 5.1 Bonding 5.2 Assembly (Die Bonding, wire Bonding & Encapsulation) 5.3 Ceiling 5.4 Marking 5.5Failure Analysis using AI for Semiconductor Packages	**CO5**

J) Suggested Laboratory Experiences:

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
LSO 1.1 Design the package of given spec	1.	Design of semiconductor package in CAD tool	CO1
LSO 2.1 Fabricate the Package of given design	2.	Fabrication of Semiconductor Package using 3D printing & lid and pin attachment	CO2
LSO 3.1 Perform Die Bonding and visual inspection	3.	Dicing and Die bonding of device on chip and visual test	CO4
LSO 4.1 Perform Wire Bonding and analyse the bonding	4.	Wire bonding from device to package-post and bond-pull test	CO4
LSO 5.1. Perform encapsulation and measure hardness.	5.	Encapsulation, curing, sealing and hardness measurement	CO5
LSO 6.1. Analyse Discrete Devices' behaviour	6.	Testing and electrical characterization of discrete device	CO5

K) Suggested Research Based Problems

i. Investigations on wire bond strength and analysis of process and material parameters
ii. Study of epoxy die bond strength with curing temperature
iii. Investigation of diced semiconductor chip and process optimization
iv. AI-Based Multi-Objective Optimization for Semiconductor Packaging Process Parameters
v. Predictive Maintenance of Semiconductor Packaging Equipment Using AI and IoT Sensor Data

Note: Depending on the requirement of each laboratory experience, micro project and research-based problems, the performance may be conducted in online/offline mode and accordingly appropriate assessment tools may be used.

L) Suggested Term Work (TW): The term work/self-learning must be according to the Hrs. assigned. This may be in the form of assignments/micro projects

a. Assignment(s):

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

- To obtain design parameters/ prerequisites and to create a pre-design sheet for designing package for a specific device
- To generate a process-sequence with process parameters for fabrication of package with pin-assembly for semiconductor devices using 3D printing
- To provide process-steps with parameter values for assembly of semiconductor chip device using die- and wire- bonding and its encapsulation for obtaining a packaged device
- To explore the materials used (substrates, bonding wires, underfills, molding compounds) and analyze their effect on thermal performance and durability and submit a report.

b. Micro Projects: -

- Diffusion
- Design of package for semiconductor devices as per given specifications using CAD tools
- Fabrication of package with pin-assembly for semiconductor devices using 3D printing and other techniques
- Assembly of semiconductor chip device using die- and wire- bonding and its encapsulation for realization of packaged device
- AI-Based Optical Defect Detection in Semiconductor Packaging
- Machine Learning for Predicting Packaging Yield Based on Process Parameters.

M) Suggested Specification Table for End Semester Theory Assessment (ETA): Questions may be designed based on the higher taxonomy level of cognitive domain.

COs	Relevant Unit Number and Title	Marks
CO1	Unit-1.0 Essentials of Packaging	12
CO2	Unit-2.0 Design Aspects of Packaging	12
CO3	Unit-3.0 Dicing & Inspection	16
CO4	Unit-4.0 Conventional Packaging	16
CO5	Unit-5.0 Customized Packaging	14
Total		**70**

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. 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. To ensure learning, research-based problems may be designed and implemented.

O) Major Equipment, Tools and Software for Laboratory and Research Work:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience /Practical Number
1.	Computer system	Processor Intel Core i5, 4 GB RAM, 15 GB free disk space	All
2.	Solid works/ NX-CAD Software	S/w	All
3.	Clean Room Setup	Under process	All

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience /Practical Number
4.	Dicing machine, wire bonder, die bonder, oven, 3D printer	Available	All

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition withISBN
1.	Electronic Packaging and Interconnection Handbook	Charles Harper	McGraw-Hill Professional Edition: 4, ISBN-13, 978-0071430487, November 2004
2.	Semiconductor Packaging Material Interaction and reliability	Chen, Andrea & Lo, Randy Hsiao-Yu	ISBN-13; 978-1439862056 CRC Press, 10 October 2011
3.	Microelectronics Packaging Handbook, Vol II: Semiconductor Packaging	R.R. Tummala, Eugene J. Rymaszewski & Alan G. Klopfenstein	Springer / Chapman & Hall, 1997, 0412084414 / 9780412084416
4.	Semiconductor Advanced Packaging	John H. Lau	Springer, 2021, 9811613753 / 9789811613753
5.	Fundamentals of Semiconductor Manufacturing and Process Control	Michael Quirk & Julian Serda	Pearsons, 2001, 0130815209
6.	Semiconductor Devices: Basic Principles	Jasprit Singh	Wiley, 2007, 8126511028 / 9788126511020

b) Online Educational Resources (OER):

1) **Introduction to Semiconductor manufacturing,**
https://www.udemy.com/course/introduction-to-semiconductor-manufacturing/?utm_source=adwords&utm_medium=udemyads&utm_campaign=DSA_Catchall_la.EN_cc.INDIA&campaigntype=Search&portfolio=India&language=EN&product=Course&test=&audience=DSA&topic=&priority=&utm_content=deal4584&utm_term=_._ag_82569850245_._ad_533220805577_._kw__._de_c_._dm__._pl__._ti_dsa-52949608673_._li_9061770_._pd__._&matchtype=&gad_source=1&gclid=CjwKCAjwtNi0BhA1EiwAWZaANF7_kHMGZHDYUZG79XBj68oVwpY2OcPJmbyPtlb3FWCrmderG5s0rRoCMhsQAvD_BwE&couponCode=IND21PM

2) **Introduction to Semiconductor Packaging,**
https://www.coursera.org/learn/introduction-to-semiconductor-packaging

Q) Course Curriculum Development Team

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A)	**Course Title:** Basics of Artificial Intelligence and Machine Learning	Deemed to be University under Distinct Category
B)	**Course Code:** CSEB05	
C)	**Pre- requisite (s):**	

D) **Rationale:** Artificial Intelligence and Machine Learning are no longer confined to computer science; they are transformative technologies impacting every engineering discipline. From optimizing civil infrastructure designs, predicting material failures in mechanical systems, enhancing power grid efficiency in electrical engineering, to developing intelligent control systems, AI/ML offers unparalleled tools for problem-solving, efficiency, and innovation.

Therefore, this course is important for all disciplines. This course will equip learners with foundational knowledge in data-driven decision-making, predictive analytics, and automation. Regardless of their specialization, the comprehension of AI/ML will enable them to leverage these technologies to create smarter products, optimize processes, interpret vast datasets, and remain competitive in a rapidly evolving AI-driven industrial landscape.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following industry expected course outcomes by the learners.

Course Outcomes (COs)	Course Outcome Statements
CSEB05.CO1	Develop Python programs for solving mathematical problems.
CSEB05.CO2	Manipulate Sequence data types in Python
CSEB05.CO3	Analyse the data using Python Libraries, modules, and Packages
CSEB05.CO4	Apply various Machine learning paradigms.
CSEB05.CO5	Evaluate the performance of the prediction model after creating it.
CSEB05.CO6	Analyse data using various tools for AI & ML Applications.

F) Suggested Course Articulation Matrix (CAM): (To be prepared by the curriculum development committee of the respective programme)

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
CSEB05	PCC	Basics of Artificial Intelligence and Machine Learning	30	15	45	30	120	04	30	70	20	-	20	30	170

H) Course Curriculum Detailing: For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP 2020, unique features like green skills, multidisciplinary aspects, societal connect, IKS, renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Differentiate between Procedure-Oriented and Object-Oriented Programming approaches with examples. *TSO 1b.* Explain the concept of Lvalue and Rvalue *TSO 1c.* Write Python program using various data types and operators *TSO 1d.* Write Python program using decision-making statements. *TSO 1e.* Write Python Program using loop structure to solve iterative problems.	**Unit-1.0 Basics of Python Programming** 1.1 Procedure oriented vs. Object-Oriented approach of programming 1.2 Python character set, Python tokens, variables, concept of Lvalue and Rvalue, use of comments. 1.3 Data types: number (integer, floating point, complex), Boolean, sequence (string, list, tuple), none, mapping (dictionary), mutable and immutable data types 1.4 Operators: arithmetic operators, relational operators, logical operators, assignment operator, augmented assignment operators. Expressions, statements, type conversion & input/output: precedence of operators, expressions, and evaluation of expressions.	**CO1**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
	1.5 Conditional statements: simple if statement, if-else statement, if-elif-else statement 1.6 Iterative statements: while loop, for loop, range function, break and continue statements, nested loops	
TSO 2a. Explain the procedure to perform the various operations on a string using string operators and methods. *TSO 2b.* Explain the procedure to perform various operations on a List using list operators and methods *TSO 2c.* Explain the procedure to perform various operations on tuples using tuple operators and methods *TSO 2d.* Explain the procedure to perform various operations on a set using set methods *TSO 2e.* Explain the procedure to perform various operations on a dictionary using dictionary methods. *TSO 2f.* Explain the procedure to create and use user-defined functions to implement a modular programming approach. *TSO 2g.* Explain the working of the scopes of variables.	**Unit 2.0: Sequence data types, Functions.** 2.1 String: indexing, string operations (concatenation, repetition, membership & slicing), traversing a string using loops, and built-in functions. 2.2 Lists: introduction, indexing, list operations: concatenation, repetition, membership & slicing, traversing a list, built-in list functions, linear search on a list of numbers, and counting the frequency of elements in a list 2.3 Tuples: Creating, initializing, accessing elements, tuple assignment, performing operations on tuples, tuple methods and built-in functions, nested tuples 2.4 Set: Creating sets, traversing, adding, removing data in a set, performing set operations like join, Union, intersection, difference 2.5 Dictionary: accessing items in a dictionary using keys, mutability of dictionary: adding a new item, modifying an existing item, built-in dictionary functions. 2.6 Functions: types of function (built-in functions, functions defined in module, user-defined functions), creating user user-defined function, arguments and parameters, default parameters, positional parameters, Lambda functions, returning value, scope of a variable: global scope, local scope	**CO2**
TSO 3a. Write simple Python programs with an object-oriented approach *TSO 3b.* Explain the workflow to use the constructors and destructors appropriately in a Python program *TSO 3c.* Write the program to implement the given type of inheritance in Python. *TSO 3d.* Explain the procedure to implement the concept of Polymorphism in Python *TSO 3e.* Write Python programs for exception handling in Python *TSO 3f.* Differentiate between different modes	**Unit-3.0 OOPS, Data Analysis using Modules and Packages** 3.1 Object-oriented programming concepts and approach, Abstraction, encapsulation, class, object, class method vs static method in Python, class and static variable, constructor and destructors in Python. 3.2 Inheritance: single, multiple, multilevel, hierarchical inheritances	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
of file opening. *TSO 3g.* Explain the procedure to perform read, write, and Append operations in files *TSO 3h.* Explain the procedure to import and use Python modules, libraries, and Packages. *TSO 3i.* Write the procedure to apply the Pandas data structure for data analysis *TSO 3j.* Illustrate the process of using Pandas to perform various operations and functions on series. *TSO 3k.* Explain the procedure to perform the various operations in a Data Frame's columns and rows *TSO 3l.* Write a program to read and write on CSV, XLS, and Text data files *TSO 3m.* Write the procedure to use the various data cleaning operations and prepare data.	3.3 Polymorphism: Polymorphism with class method, polymorphism with inheritance, method overriding, and overloading. 3.4 Exception Handling: syntax errors, exceptions, need for exception handling, user-defined exceptions, raising exceptions, handling exceptions, catching exceptions, Try - except - else clause, Try - finally clause, recovering and continuing with finally, built-in exception classes. 3.5 File Handling: text file and binary file, file types, open and close files, reading and writing text files, reading and writing binary files, file access modes 3.6 Modules and Packages: Importing modules using 'import', Regular Expressions, Exception Handling, PyPI Python Package Index, Pip Python package manager, Importing Libraries and Functions 3.7 Key features and methods for summarizing data in Python, Aggregation and Grouping, data visualization. 3.8 Pandas data structures: Series, Declaration, selecting elements, assigning values, Filtering values, operations, mathematical functions, evaluating values, handling missing data, creating series from dictionaries, adding two series. 3.9 Data Frame: Defining, selecting elements, assigning values, membership, deleting a column, and filtering. Index Objects: Indexing, Re-indexing, Dropping, sorting and ranking, Descriptive Statistics 3.10 Data Loading: Reading and Writing CSV, xls, Text Data Files, Data Cleaning and Preparation: Handling missing data, removing duplicates, replacing values, Vectorized String Methods, Hierarchical Indexing, Merging and Combining, Data aggregation and Grouping.	
TSO 4a. Explain the concept of Artificial Intelligence. *TSO 4b.* Differentiate the various learning paradigms. *TSO 4c.* Explain the use of a suitable machine learning algorithm for the given application.	**Unit-4.0 Introduction to AI & ML** 4.1 Overview of AI: Agents, Natural Language Processing & Decision Network 4.2 Learning Paradigms: Supervised, Unsupervised and Reinforcement Learning. 4.3 ML Algorithms: Supervised Learning Algorithms: Linear Regression, Logistic	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 4d. Explain the procedure for validating the machine learning algorithm.	Regression, Random Forest, k-NN, Decision Tree, SVM, ANN, 4.4 Unsupervised Learning Algorithms: k-Means clustering and k-Mode Clustering 4.5 Reinforcement Learning Algorithm: Q-Learning.	
TSO 5a. Explain the process of exploring the various datasets to identify their characteristics and patterns. *TSO 5b.* Perform the feature scaling for the given dataset. *TSO 5c.* Perform the feature selection process on the given dataset. *TSO 5d.* Explain the procedure to create a model using data preprocessing and classification. *TSO 5e.* Explain the procedure to create multidisciplinary applications.	**Unit-5.0 Model Creation using Python** 5.1 Datasets: Kaggle, UCI Machine Learning Repository 5.2 Data Pre-processing: Feature Scaling and Feature Selection 5.3 Model creation using data pre-processing, Classification through ML algorithms using Python programming. 5.4 Creation of Multidisciplinary Applications	**CO5**
TSO 6a. Explain the role of AI and ML algorithms in decision-making on various applications. *TSO 6b.* Explain the features of the Weka Tool *TSO 6c.* Explain the features of the Orange3 Tool *TSO 6d.* Explain the features of Julia Tool *TSO 6e.* Differentiate the features of Weka, Orange3, and Julia. *TSO 6f.* Perform data preprocessing using Weka, Orange3, and Julia AI. *TSO 6g.* Explain the process of using classifiers for classification in Weka, Orange3, and Julia AI. *TSO 6h.* Use clustering methods for grouping the given data in Weka, Orange3, and Julia AI.	**Unit 6.0: Applications of AI & ML and Data Analysis Tools** 6.1 Role of AI & ML in Multidisciplinary, Applications 6.2 Introduction to Weka, Orange3, and Julius AI 6.3 Data pre-processing: Data cleaning, Removal of Stop words, Removal of Null values using Tools such as Weka, Orange3, and Julius AI 6.4 Data Visualization: Bar Chart, Pie Chart, Line Chart, Plot, etc. in Weka, Orange3, and Julius AI. 6.5 Classification through Weka, Orange3, and Julius AI 6.6 Regression through Weka, Orange3, and Julius AI 6.7 Clustering Process using Weka, Orange3, and Julius AI	**CO6**

J) Suggested Laboratory experiences:

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
LSO 1.1. Implement conditional statements in Python.	1.	Write Python programs to demonstrate the use of the following conditional statements:	CO1

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
		a. If statements b. If-else statements, if-elif-else statements	
LSO 2.1. Implement Loop statements in Python to solve iterative problems.	2.	Write Python programs to demonstrate the use of the following loop statements: a) While loop b) for loop c) Use of range function, break, continue	CO1
LSO 3.1. Manipulate given Sequence data types in Python	3.	Write and execute Python Programs to demonstrate various operations on the following sequence data types: a) String b) List	CO2
		Write and execute Python Programs to demonstrate various operations on the following sequence data types: a) Tuple b) Set, c) Dictionary	CO2
LSO 5.1. Create user-defined functions in Python	4.	Write and execute Python Programs to demonstrate creating and calling User-defined functions	CO2
LSO 5.1. Use NumPy and Pandas built-in functions	5.	Consider a dataset, and execute the following functions to analyze the dataset. a) Read, head, tail & arithmetic functions b) Loc (Location), iloc (Integer Location) c) Sort, Numpy with Arrays.	CO3
LSO 6.1 Use Python modules.	6.	Conduct a statistical learning process using the Chi-Square test by considering the parametric and Non-parametric tests.	CO3
LSO 7.1. Visualize the given data in various dimensions. *LSO 7.2.* Summarize the data according to the dataset's features.	7.	a) Demonstrate the data visualization of the given data. b) Summarize the data with respect to the different attributes of the given salary dataset.	CO3
LSO 8.1. Apply Linear Regression and Multiple Linear Regression for predictive analysis.	8.	a) Perform the predictive analysis using Multiple Linear Regression. b) Perform the predictive analysis using Linear Regression.	CO4

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
LSO 8.2. Evaluate the Linear and Multiple Linear Regression models with respect to the standard evaluation metrics.		c) Compare the performance of the Multiple Linear Regression and Linear Regression with respect to the prediction accuracy and time.	
LSO 9.1. Implement the resampling process and feature selection using Python. *LSO 9.2.* Apply the k-nearest neighbor classifier to perform the predictive analysis. *LSO 9.3.* Evaluate the k-nearest neighbour with respect to the evaluation metrics.	9.	a) Perform the resampling process and feature selection using a suitable ML classifier. b) Perform the predictive analysis using k-Nearest Neighbor by considering the dataset with selected features. c) Evaluate the k-nearest neighbour classifier with respect to the standard evaluation metrics like precision, recall, f-measure and accuracy.	CO3, CO4
LSO 10.1. Solve the MCNFP problem for the optimal solution using Python. *LSO 10.2.* Evaluate the efficiency of the MCNFP in the process of optimization.	10.	Implement the Minimum Cost Network Flow Problem (MCNFP) method to find the new path in a transportation network.	CO3, CO4
LSO 11.1. Implement the stochastic decision tree to predict the risk. *LSO 11.2.* Evaluate the performance of the stochastic decision tree by using the evaluation metrics.	11.	Implement the stochastic decision tree algorithm to analyze the risk. (Prefer your own dataset)	CO3, CO4
LSO 12.1. Predict the future result by analyzing the given data using the Random Forest algorithm. *LSO 12.2.* Evaluate the performance of the classifier with respect to the standard evaluation metrics.	12.	a. Execute the source code of the random forest algorithm implementation for predicting diabetic and heart diseases b. Compare the performance of the random forest with k-nearest neighbor by considering the standard evaluation metrics.	CO3, CO4
LSO 13.1 Predict the future result by analyzing an image dataset using the SVM algorithm. *LSO 13.2* Evaluate the performance of the classifier with respect to the standard evaluation metrics. *LSO 13.3* Compare the performance of the SVM with MLP with respect to the standard evaluation metrics.	13.	a) Implement the support Vector Machine (SVM) algorithm for image classification/ semantic segmentation (choose any dataset) b) Evaluate the algorithm's performance with respect to the standard classifiers. c) Compare the performance of the SVM with the Multi-layer perceptron (MLP) by considering the standard evaluation metrics.	CO3, CO4
LSO 14.1 Visualize the given dataset using the Weka Tool.	14.	a) Perform the data visualization using the Weka Tool.	CO5, CO6

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
LSO 14.2 Visualize the given dataset using the Orange3 Tool. *LSO 14.3* Visualize the given dataset using the Julia AI tool.		b) Perform the data visualization using the Orange3 Tool. c) Perform the data visualization using the Julia AI tool.	
LSO 15.1 Preprocess the given dataset using the Weka Tool. *LSO 15.2* Preprocess the given dataset using the Orange3 Tool. *LSO 15.3* Preprocess the given dataset using the Julia AI tool.	15.	a) Perform the data preprocessing on the given dataset using the Weka Tool. b) Perform the data preprocessing on the given dataset using the Orange3 Tool. c) Perform the data preprocessing on the given dataset using the Julia AI tool.	CO5, CO6
LSO 16.1 Classify the given dataset using the Weka Tool. *LSO 16.2* Classify the given dataset using the Orange3 Tool. *LSO 16.3* Classify the given dataset using the Julia AI tool.	16.	a) Perform the classification process on the given dataset using the Weka Tool. b) Perform the classification process using the Orange3 Tool. c) Perform the classification process using the Julia AI tool	CO5, CO6

K) Suggested Research Based Problems

i. Demonstrate the performance of the Multilayer Perceptron and Artificial Neural Network over a seizer dataset with respect to the detection accuracy and time.

ii. Develop a product recommendation system using a stochastic decision tree algorithm by analyzing a sales dataset. Further, the system needs to recommend the product requirement for the specific year and the required quantity to fulfill the customer needs with satisfaction.

Note: Depending on the requirement of each laboratory experience, micro project and research-based problems, the performance may be conducted in online/offline mode and accordingly appropriate assessment tools may be used.

L) Suggested Term Work (TW):

a. Assignment(s):

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

b. Seminar Topics:

- Python Libraries and Packages used in data analytics
- Comparison of various Data Visualization tools
- Role of predictive analysis in real-time applications

- ML algorithms in Decision Making
- ML algorithms in feature engineering
- Weka Vs Orange3 Vs Julia AI
- Role of AI and ML in Multidisciplinary Research

M) Suggested Specification Table for End Semester Theory Assessment (ETA): Questions may be designed based on the higher taxonomy level of cognitive domain.

COs	Relevant Unit Number and Title	Marks
CO1	Unit 1.0 Basics of Python Programming	10
CO2	Unit 2.0 Sequence data types, Functions.	10
CO3	Unit 3.0 OOPS, Data Analysis using Modules and Packages	10
CO4	Unit 4.0 Introduction to AI & ML	15
CO5	Unit 5.0 Model Creation using Python	15
CO6	Unit 6.0 Applications of AI & ML and Data Analysis Tools	10
Total		**70**

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies: Different instructional/implementation strategies may be appropriately used in online and offline modes, as per the requirement of the outcome to be achieved. 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. To ensure learning, research-based problems may be designed and implemented.

O) Major Equipment, Tools and Software for Laboratory and Research Work:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience /Practical Number
1.	Computer system	Processor Intel Core i7, 32 GB RAM, 15 GB free disk space	All
2.	Integrated Development and Learning Environment (IDLE)	S/w to be downloaded for Python 3.11.3 or higher	1-13
3.	Anaconda Navigator / Jupyter NoteBook	Server for Software Platform	1-13
4.	Weka	Software Tool	14,15 & 16

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience /Practical Number
5.	Orange3	Software Tool	14,15 & 16
6.	Julia AI	Software Tool	14,15 & 16

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Python for Programmers	Paul Deitel and Harvey Deitel	Pearson Education, 1st Edition, 2021 ISBN-10 : 9353947987 ISBN-13 : 978-9353947989
2.	Artificial Intelligence – A Modern Approach	Stuart Russell and Peter Norvig	Fourth Edition, Pearson Education, 2021. ISBN-10 : 1292401133 ISBN-13 : 978-1292401133
3.	Machine Learning: An Algorithmic Perspective	Stephen Marsland	Chapman & Hall/CRC, 2nd Edition, 2014. ISBN-10 : 1138583405 ISBN-13 : 978-1138583405
4.	Data Analytics and Decision Making	Ali Abdul Hussein	Creative Commons Attribution 4.0 International License, University of Windsor, 2022.
5.	Python Data Analytics	Fabio Nelli	Apress,2015 ISBN: 9781484209585
6.	Python for Data Analysis: Data Wrangling with Pandas, Numpy, and Python	Wes McKinney	O'REILLY, 2017, Second Edition ISBN-10: 1491957662 ISBN-13:78-1491957660

b) Online Educational Resources (OER):

1) https://docs.python.org/3/tutorial/
2) https://nptel.ac.in/courses/106106145
3) https://www.w3schools.com/python/
4) https://www.tutorialspoint.com/python/index.htm
5) https://www.w3schools.com/python/pandas/default.asp
6) https://pandas.pydata.org/docs/user_guide/10min.html
7) http://bedford-computing.co.uk/learning/wp-content/uploads/2015/10/Python-Cookbook-3rd-Edition.pdf

8) Data Sources:
   - 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

- https://www.kaggle.com/datasets/johnsmith88/heart-disease-dataset
- https://www.kaggle.com/datasets/harunshimanto/epileptic-seizure-recognition
- https://www.kaggle.com/datasets/mathchi/diabetes-data-set

Q) Course Curriculum Development Team

S. No.	Name	E-mail Address
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A)	**Course Title:** Sports, Yoga & Meditation	Deemed to be University under Distinct Category
B)	**Course Code:** NEP01	
C)	**Pre- requisite (s):**	

D) **Rationale:** Sports or Physical Education, Yoga and Meditation is an integral part of a person's overall well-being and is imperative for a healthy mind and body balance. Integrating practical activities throughout the curriculum ensures that students not only gain theoretical knowledge but also develop practical skills, enhance their physical and mental well-being, and cultivate a deeper understanding and appreciation for sports, yoga, and meditation. Practical learning experiences are essential for reinforcing concepts, building competence, and fostering a lifelong commitment to health and wellness practices. It's also plays a major role in reducing level of stress/anxiety and add to the mental toughness. Looking to the ample benefits there is need to inculcate sports, Yoga and meditation as a day to day habit. So, it is necessary that every educational institutes should lay ample emphasis on including sports, yoga and meditation as a necessary part of education.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following industry expected course outcomes by the learners.

Course Outcomes (COs)	Course Outcome Statements
NEP01.CO1	Select appropriate physical activities to maintain healthy lifestyle.
NEP01.CO2	Apply basic principles and practices of Yoga and meditation for overall growth & development.
NEP01.CO3	Use fitness and wellness techniques for optimal health and wellbeing

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)		
	PO-1 An ability to independently carry out research /investigation and development work to solve practical problems.	**PO-2** An ability to write and present a substantial technical report/document.	**PO-3** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
NEP01.CO1	2	1	1
NEP01.CO2	2	1	1
NEP01.CO3	2	1	1

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		Total Marks (TA+TWA+LA)
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
NEP01	NEP	Sports, Yoga & Meditation	15	-	-	15	30	01	25	-	25	-	-	-	50

H) Course Curriculum Detailing: For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP 2020, unique features like green skills, multidisciplinary aspects, societal connect, IKS, renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Describe various sports, their benefits, and basic rules. *TSO 1b.* Explain the importance of physical fitness and basic conditioning exercises. *TSO 1c.* Select sports and exercises for physically challenged as per their need. *TSO 1d.* Explain the components of physical fitness (strength, flexibility, endurance). *TSO 1e.* Demonstrate proficiency in performing warm- up and cool-down routines. *TSO 1f.* Apply basic strength training and flexibility exercises to improve fitness levels.	**Unit-1.0 Introduction to Sports** 1.1 Definition of play, game, sports, exercise, psychology, sports psychology and exercise psychology, psychology and common-sense Overview of popular sports (football, basketball, tennis, etc.) 1.2 Benefits of sports for physical health and teamwork 1.3 Basic rules and equipment of selected sports 1.4 Components of physical fitness (strength, flexibility, endurance) 1.5 Warm-up and cool-down routines 1.6 Introduction to strength training and flexibility exercises 1.7 Adaptation of sports and exercises for physically challenged students in all levels.	**CO1**
TSO 2a. Apply principles and practices of yoga. *TSO 2b.* Explore techniques for mental relaxation and focus. *TSO 2c.* Explain history, philosophy, and principles of yoga. *TSO 2d.* Practice basic yoga asanas (poses) and their benefits. *TSO 2e.* Practice breath control (pranayama) and relaxation techniques effectively. *TSO 2f.* Develop a structured sequence of yoga poses for specific purposes (strength, flexibility, relaxation). *TSO 2g.* Integrate meditation techniques as part of their yoga practice. *TSO 2h.* Describe the benefits of meditation and mindfulness practices. *TSO 2i.* Apply mindfulness techniques to enhance focus, reduce stress, and improve overall well- being. *TSO 2j.* Select yoga and meditation for physically challenged as per their need.	**Unit-2.0 Yoga and Meditation** 2.1 History and philosophy of yoga 2.2 Role of yoga and meditation in purificatory process, in character building, developing concentration, will power and discipline 2.3 Types of yoga practices - asanas, pranayama, meditation 2.4 Basic yoga asanas (poses) and their benefits 2.5 Importance of breath control (pranayama) and relaxation techniques 2.6 Intermediate yoga asanas and their variations 2.7 Sequencing of yoga poses for different purposes (strength, flexibility, relaxation) 2.8 Introduction to meditation techniques 2.9 Benefits of meditation and mindfulness practices 2.10 Techniques: mindfulness meditation, guided visualization, body scan 2.11 Application of mindfulness in daily life and sports performance 2.12 Adaptation of yoga and meditations for physically challenged students in all levels	**CO2**
TSO 3a. Describe the mental aspects of sports and performance. *TSO 3b.* Apply skills learned in sports, yoga,	**Unit-3.0 Sports, Mental Conditioning and Integration** 3.1 Mental preparation techniques for sports	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
and meditation in practical settings *TSO 3c.* Integrate physical fitness, yoga, and mental conditioning into a comprehensive wellness routine. *TSO 3d.* Create and implement personalized fitness and wellness plans based on learned principles.	3.2 Goal setting and visualization 3.3 Overcoming performance anxiety and stress management 3.4 Integration of physical fitness, yoga, and mental conditioning 3.5 Creating personal fitness and wellness routines	

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

a. Develop nutritional guidelines and programs that result in measurable improvements in athletic performance and recovery times.

b. Develop comprehensive mental health programs that effectively reduce anxiety, depression, and burnout in athletes.

c. Identify yoga practices that results in measurable improvements in mental health outcomes such as reduced stress, anxiety, and depression.

d. Identify and study specific neurobiological changes due to yoga, leading to enhanced mental and physical health.

e. Develop and validate meditation practices that significantly reduce symptoms of anxiety, depression, and PTSD.

f. Investigate group meditation dynamics that result in improved mental health outcomes and increased group cohesion.

Note: Depending on the requirement of each laboratory experience, micro project and research-based problems, the performance may be conducted in online/offline mode and accordingly appropriate assessment tools may be used.

L) Suggested Term Work (TW):

a. Assignments: (Seminar Topics/ Visits/ Self- Learning Topics)
Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

- Calculate your Body Composition (BMI) and Cardiovascular Assessment
- Assessment for Muscular Endurance, Muscular Strength,
- Flexibility, Cardio-respiratory Endurance, Body Composition
- Rules and Regulations of different indoor and outdoor games.

b. Seminar Topics:

- Ethics in sports
- Application of principles of yoga in daily life.
- Strategies to Incorporate mindfulness practices into everyday activities

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

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. 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. To ensure learning, research-based problems may be designed and implemented.

O) Major Equipment, Tools and Software Research Work:

S. No.	Name of Equipment, Tools and Software	Broad Specifications
1.	Soccer Ball	Size 5, made of synthetic leather, weight 410-450g
2.	Tennis Racket	Length 27 inches, strung with synthetic gut, weight 280-300g
3.	Badminton racket and net	-
4.	Table tennis racket and net	-
5.	Basketball	Size 7, made of leather, weight 567-650g
6.	Base ball set	-
7.	Cricket bat and ball	-
8.	Hockey sticks and balls	-
9.	Javelin Throw	Length: 2.6 - 2.7 meters (8 ft 6 in - 8 ft 10 in) Weight: 800 grams Material: Metal head with a hollow or solid shaft
10.	Discus Throw	Weight: 2 kg for men, 1 kg for women Diameter: 22 cm for men, 18 cm for women Circle Diameter: 2.5 meters (8.2 ft) Material: Made of metal, smooth surface
11.	Shot Put	Weight: 7.26 kg for men, 4 kg for women Diameter: 110-130 mm (4.3-5.1 inches) for men, 95-110 mm (3.7-4.3 inches) for women Circle Diameter: 2.135 meters (7 ft) Material: Made of steel
12.	Chess, carrom	Chess and carrom set
13.	Resistance Bands	Various resistance levels, latex material
14.	Dumbbells	1-10 lbs, adjustable weights

S. No.	Name of Equipment, Tools and Software	Broad Specifications
15.	Jump Rope	Adjustable length, durable material
16.	Exercise Mat	Non-slip surface, cushioned, 68 x 24 inches
17.	Step Platform	Adjustable height, sturdy, non-slip surface
18.	Hand Weights	1-5 lbs, ergonomic grip
19.	Heart Rate Monitor	Wrist-worn, accurate readings
20.	Fitness Ball	55-75 cm diameter, anti-burst material
21.	Aerobics mats -	• Thickness- approx. 1/4 to 1/2 inch for adequate cushioning • Material- Non-slip PVC, rubber, or foam • Size-minimum 68 x 24 inches and larger sizes • Portability- Lightweight and easy to roll up • Durability- Tear-resistant and easy to clean • Design- Textured surface for better grip • Weight- Lightweight (around 2-3 pounds) for easy transport
22.	Sports Wheelchairs	Customized for different sports, lightweight, adjustable
23.	Adaptive Bicycles	Handcycles, tricycles, recumbent bikes
24.	Modified Dumbbells	Adjustable grips for different hand sizes and strength levels
25.	Adaptive Treadmills	Hand-cranked or wheelchair-accessible treadmills
26.	Prosthetics	High-performance prosthetics for running, swimming, etc.
27.	Adaptive Yoga Mat	1/4-inch-thick, non-slip surface, 68 x 24 inches, extra cushioning for support
28.	Yoga Blocks	4 x 4 x 9 inches and various sizes, made of cork or foam
29.	Yoga Strap	6 feet long, adjustable buckle, Adjustable length, made of nylon
30.	Blanket	72 x 48 inches, made of cotton, lightweight
31.	Water Bottle	500ml capacity, BPA-free plastic, leak-proof
32.	Yoga Bolsters	Soft, supportive, various sizes
33.	Chair Yoga Props	Sturdy chairs with low back, no arms
34.	Meditation Cushion	12 x 12 inches, filled with buckwheat hulls or foam, supportive cushions
35.	Meditation Bench	12 inches wide, 18 inches long, adjustable height, comfortable seating
36.	Meditation Bell	2 inches in diameter, made of brass, produces clear sound
37.	Timer	Digital, with a soft alarm sound, battery-operated
38.	Essential Oil Diffuser	100ml capacity, adjustable mist settings, made of ceramic
39.	Blood pressure equipment	Blood pressure equipment

S. No.	Name of Equipment, Tools and Software	Broad Specifications
40.	Blood sugar equipment	Blood sugar equipment
41.	Massage therapy equipment, Hot and cold therapy equipment, Ultrasound therapy equipment for pain relief.	Massage therapy equipment, Hot and cold therapy equipment, Ultrasound therapy equipment for pain relief.
42.	Safety accessories	Helmet, Mouthguards, Protective Eyewear, Shin Guards, Knee Pads, Elbow Pads,Wrist Guards, Padded Shorts, Safety Harnesses, Life Jackets, etc

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Practical Applications in Sports Nutrition	Heather Hedrick Fink, Alan E. Mikesky	Jones & Bartlett Learning (2020) ISBN No: 978-1284181340
2.	ACSM's Guidelines for Exercise Testing and Prescription	Gary Liguori	LWW; (2021) ISBN-13: 978-1975150198
3.	Essentials of Strength Training and Conditioning	Javair Gillett	Human Kinetics, (2021) ISBN-13: 978-1718210868
4.	Practical Applications in Sports Nutrition	Heather Hedrick Fink, Alan E. Mikesky	Jones & Bartlett Learning, (2017) ISBN-13: 978-1284101393
5.	Health Fitness Management	Mike Bates, Mike Spezzano, Guy Danhoff	Human Kinetics, (2019) ISBN-13: 978-1450412230
6.	Yoga for Every Body: A beginner's guide to the practice of yoga postures, breathing exercises and meditation	Luisa Ray, Angus Sutherland	Vital Life Books (2022) ISBN-13: 978-1739737009
7.	Science of Yoga: Understand the Anatomy and Physiology to Perfect Your Practice	Ann Swanson	DK Publisher, (2019) ISBN-13: 978-1465479358
8.	Mudras for Modern Living: 49 inspiring cards to boost your health, enhance your yoga and deepen your meditation Cards	Swami Saradananda	Watkins Publishing (2019) ISBN-13: 978-1786782786
9.	Counselling Skills in Applied Sport Psychology: Learning How to Counsel	Paul McCarthy, Zoe Moffat	Routledge, (2023) ISBN-13: 978-1032592589
10.	Advancements in Mental Skills Training (ISSP Key Issues in Sport and Exercise Psychology)	Maurizio Bertollo, Edson Filho, Peter Terry	Routledge, (2020) ISBN-13: 978-0367111588
11.	The Relaxation and Stress Reduction Workbook	Martha Davis, Elizabeth Robbins, Matthew McKay, Eshelman MSW	A New Harbinger Self-Help Workbook (2019)
12.	Patanjalis Yoga Sutras	Swami Vivekananda	Fingerprint Publishing (2023) Prakash Books India Pvt Ltd, New Delhi ISBN-13: 978-9354407017

b) Online Educational Resources (OER):

1) https://onlinecourses.swayam2.ac.in/aic19_ed28/preview- introduction to Yoga and Applications of Yoga
2) https://onlinecourses.swayam2.ac.in/aic23_ge09/preview- Yoga for Creativity
3) https://onlinecourses.swayam2.ac.in/aic23_ge05/preview- Yoga for concentration
4) https://onlinecourses.swayam2.ac.in/aic23_ge06/preview- yoga for memory development
5) https://onlinecourses.nptel.ac.in/noc21_hs29/preview-Psychology of Stress, Health and Well being
6) https://onlinecourses.swayam2.ac.in/nce19_sc04/preview- Food Nutrition for Healthy Living - Course – Swayam
7) https://www.classcentral.com/course/swayam-fitness-management-17608- Fitness Management from Swayam
8) https://onlinecourses.swayam2.ac.in/nce19_sc04/preview-Food Nutrition for Healthy Living
9) https://onlinecourses.swayam2.ac.in/cec21_ed02/preview Health Education and Recreation
10) https://onlinecourses.swayam2.ac.in/cec22_ed31/preview Sports Administration and Management

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A)	**Course Title:** Open Educational Resources (OER)	Deemed to be University under Distinct Category
B)	**Course Code:** NEP02	
C)	**Pre- requisite (s):**	

D) **Rationale:** OER are freely and publicly available teaching, learning, and research resources that reside in the public domain in any format or have been released under an intellectual property license that permits their free use and re-purposing by others.

Learning about Open Educational Resources (OER), copyright, and Creative Commons licenses is a valuable endeavour for content creators, users, and anyone interested in sharing knowledge and creative works.

Creative Commons licenses, offer a standardized way to grant permissions for the use and sharing of creative works. Learning about OER, copyright, and Creative Commons licenses is an ongoing process. As these fields evolve, it's important to stay informed and continue exploring new resources and practices.

After going through this course, learners will at first place have reasonable idea to explore and use various OERs useful for their course of study and secondly, be motivated for fair use of resources available to them on various platform by understanding the restrictions and legal issues related to copyright and other licensing policies.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following industry expected course outcomes by the learners.

Course Outcomes (COs)	Course Outcome Statements
NEP02.CO1	Evaluate Open Educational Resources (OER) for its authentic use.
NEP02.CO2	Use copyright material appropriately.
NEP02.CO3	Implement suitable Creative Common License.

F) Suggested Course Articulation Matrix (CAM): (Not Applicable)

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
NEP02	NEP	Open Education Resources	15	-	-	15	30	01	25	-	25	-	-	-	50

H) Course Curriculum Detailing: For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP 2020, unique features like green skills, multidisciplinary aspects, societal connect, IKS, renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Explain the difference between OER and other free educational materials. *TSO 1b.* Elaborate the challenges and benefits of using OER in a class. *TSO 1c.* Apply various aspects of evaluating OER before use *TSO 1d.* Explain the necessity to assess an OER's adaptability. *TSO 1e.* Perform preliminary search for open educational resource. *TSO 1f.* Find OER using various resources.	**Unit-1.0 Open Educational Resources** 1.1 OER - definition 1.2 What is NOT OER. 1.3 Benefits of using OER – Benefits to Students - Access to Quality Education 1.4 OER - Benefits to Faculty - Use, Improve and Share, Network and collaborate with peers, Lower Cost, Improve access to information 1.5 Challenges of Using OER – Subject Availability, Format and Material type availability, Time and Support availability 1.6 Evaluating OER – a) Clarity, Comprehensibility, and Readability, b) Content and Technical Accuracy, c) Adaptability and Modularity, d) Appropriateness and Fit, e) Accessibility 1.7 Finding Open Content - OER Search Scenario Filter by Usage Rights in Google, Repositories	**CO1**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
	and Search Tools, Subject-specific Repositories	
TSO 2a. Explain benefits of copyright protection for creator *TSO 2b.* Explain exceptions and limitations to copyright law *TSO 2c.* List rights granted to copyright holders. *TSO 2d.* Explain Exceptions and limitations to copyright law *TSO 2e.* Explain Fair use/fair dealing apply to copyright *TSO 2f.* Elaborate Public domain and how does it relate to copyright *TSO 2g.* Elaborate penalties for copyright infringement. *TSO 2h.* Explain copyright for digital content and the internet. *TSO 2i.* Explain use of copyrighted works in education *TSO 2j.* Explain the use of free licenses	**Unit-2.0 Copyright and Open Licensing** 2.1 Copyright and what it does protect, benefits of copyright protection for creators, duration of copyright protection last, rights granted to copyright holders. 2.2 Exceptions and limitations to copyright law, fair use/fair dealing apply to copyright 2.3 Public domain and its relation to copyright. 2.4 Penalties for copyright infringement 2.5 Apply copyright to digital content and the internet 2.6 Use of copyrighted works in education. 2.7 Open Licenses – GNU – Free Documentation license, Free Art License 2.8 Why Free Licenses – Retain, Reuse, Revise, Remix, Redistribute	**CO2**
TSO 3a. Describe the four different Creative Commons License components. *TSO 3b.* Explain the significance of No-Derivative license *TSO 3c.* Explain the Strengths and weaknesses of four Open CC Licenses *TSO 3d.* Choose the right Creative Commons license for work. *TSO 3e.* Apply a Creative Commons license to existing work. *TSO 3f.* Use Creative Commons licenses for commercial purposes. *TSO 3g.* Modify a work licensed under Creative Commons. *TSO 3h.* Revoke a Creative Commons license, combine works with different Creative Commons licenses *TSO 3i.* Differentiate between Attribution and Citation	**Unit-3.0 Creative Common Licenses** 3.1 Alternatives to copyright as Creative Commons licenses. 3.2 Four components of creative common Licenses – Attribution, Share- Alike, Non – commercial, No Derivatives 3.3 Choosing a Creative Common licenses – Wiley's 5 Rs and Creative Common Licenses 3.4 Four Open CC Licenses and Their Strengths and Weaknesses – (a) CC BY (b) CC BY SA (c) CC BY NC (d) CC BY NC SA 3.5 Attribution Vs Citation - Creative Commons licensed work without giving attribution 3.6 Apply a CC License - choose the right Creative Commons license for work, apply a Creative Commons license to existing work, Creative Commons licenses be used for commercial purposes, modify a work licensed under Creative Commons, revoke a Creative Commons license, combine works with different Creative Commons licenses	**CO3**

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

i. Collect information on the impact of OER on cost savings and student engagement.

ii. Search at least four OER related to topic of your Engineering Discipline over Internet. Evaluate the material based on the relevance, accuracy and usability.

iii. Explore the different types of resources under creative Commons licenses (e.g., CC BY, CC BY-SA, CC BY-NC, etc.) and their specific permissions and restrictions.

iv. Create a comparative analysis chart or infographic that visually represents the key characteristics of each license. Select minimum 5 real-world examples from different domains (such as music, art, literature, or education) where creators have used Creative Commons licenses

Note: Depending on the requirement of each laboratory experience, micro project and research-based problems, the performance may be conducted in online/offline mode and accordingly appropriate assessment tools may be used.

L) Suggested Term Work (TW):

a. Assignments: (Seminar Topics/ Visits/ Self- Learning Topics)
Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

b. Seminar Topics:

- OER Quality Assurance
- OER Repositories and Platforms
- Creative Commons and Digital Media
- Creative Commons in the Visual Arts
- Examine the legal implications of using Creative Commons licenses, including the obligations and responsibilities of both creators and users and present it.

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

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. 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. To ensure learning, research-based problems may be designed and implemented.

O) Major Equipment, Tools and Software for Laboratory and Research Work: (Not Applicable)

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	The OER Starter Kit.	Abbey Elder - 2019	IA: Iowa State University Digital Press, available under a Creative Commons Attribution 4.0 International License. Retrieved from iastate.pressbooks.pub/oerstarterkit
2.	A Brief History of Open Educational Resources	Bliss, T J and Smith, M. - 2017	In: Jhangiani, R S and Biswas-Diener, R. (Eds.) Open: The Philosophy and Practices that are Revolutionizing Education and Science (pp. 9–27). London: Ubiquity Press. DOI: https://doi.org/10.5334/bbc.b.

b) Online Educational Resources (OER):

1) OER for Empowering Teachers Instructional Material by P. Malliga is licensed under a Creative Commons Attribution 4.0 International License.
2) William & Flore Hewlett Foundation. (n.d.). OER defined. Retrieved from https://hewlett.org/strategy/open-educational-resources/
3) Free Software Foundation. (2008). GNU Free Documentation License. Retrieved from https://www.gnu.org/licenses/fdl.html
4) Copyleft Attitude. (2007). Free Art License 1.3. Retrieved from http://artlibre.org/licence/lal/en/
5) Free Software Foundation. (n.d.). What is copyleft? Retrieved from https://www.gnu.org/copyleft/copyleft.html

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A)	**Course Title:** Professional Ethics	Deemed to be University under Distinct Category
B)	**Course Code:** NEP03	
C)	**Pre- requisite (s):** General awareness about moral values and about different workplaces	

D) **Rationale:** The Course on Professional Ethics equips graduates with the moral frameworks necessary to handle complex challenges inherent in any profession. In the course, graduates will be exposed to situations involving ethical dilemmas, where robust decision-making is critical for integrity, trust, and societal well-being. This course will cover concepts and principles associated with values, ethics, code of conduct, empathy, and compassion, with a view to fostering a proactive approach to ethical conduct and building resilience. It will also help to cultivate responsible leadership, enhance employability, mitigate risks, and empower individuals to contribute positively to their professions and the broader community in an increasingly interconnected world. This course is meant to sensitize students to ethical considerations within their professions and motivate them to demonstrate ethical behaviour in day-to-day activities.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following industry expected course outcomes by the learners.

Course Outcomes (COs)	Course Outcome Statements
NEP03.CO1	Make decisions considering values, moral and ethical framework.
NEP03.CO2	Propose fair professional practices considering the set of values and code of ethics in a simulated situation
NEP03.CO3	Demonstrate reasonable empathic and compassionate behaviour in professional settings.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)		
	PO-1 An ability to independently carry out research /investigation and development work to solve practical problems.	**PO-2** An ability to write and present a substantial technical report/document.	**PO-3** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
NEP03.CO1	3	3	1
NEP03.CO2	2	2	1
NEP03.CO3	2	2	1

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
NEP03	NEP	Professional Ethics	15	-	-	15	30	01	25	-	25	-	-	-	50

H) Course Curriculum Detailing: For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP 2020, unique features like green skills, multidisciplinary aspects, societal connect, IKS, renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Explain the interrelationship between values, morals and ethics. *TSO 1b.* Explain the influence of values, morals and ethics on the development of attitudes. *TSO 1c.* Identify values using self-assessment tools. *TSO 1d.* Describe a moral framework. *TSO 1e.* Use values and morally related criteria for making decisions in a given situation.	**Unit -1.0 Values, Morals and Ethics in Day-to-Day Life** 1.1 Introduction to values, moral, and ethics, definition, types of values, examples, Concept of attitude and development of attitude 1.2 Values identification using self-assessment tool, Moral Framework and its features, Importance of values and morals in day-to-day activities and at the workplace 1.3 Value-based decision criteria - Long-term versus short-term value considerations, Personal values alignment with professional choices 1.4 Moral Principles and Moral Reasoning Process	**CO1**
TSO 2a. Explain the characteristics that define a profession *TSO 2b.* Describe the role of professional associations in establishing and enforcing ethical standards. *TSO 2c.* Communicate effectively with integrity *TSO 2d.* Identify the ethical principles in the given professional codes *TSO 2e.* Suggest fair professional practices in simulated situation	**Unit-2.0 Professionalism and Codes of Conduct** 2.1 Profession and Professionalism 2.2 Role of Professional Associations and Societies 2.3 Ethics in communication**,** non-violent communication 2.4 Common Code of Ethics/Conduct for different professions, Academic ethics, environmental ethics, and Digital Ethics	**CO2**
TSO 3a. Explain the difference between compassion and empathy *TSO 3b.* Explain the role of emotional intelligence in empathy *TSO 3c.* Demonstrate empathy in a given situation *TSO 3d.* Explain the key stages for compassion development *TSO 3e.* Identify the compassion quotient using a questionnaire *TSO 3f.* Resolve ethical conflicts according to moral values and ethics. *TSO 3g.* Suggest for appropriate behaviour in a given personal and professional setting	**Unit-3.0 Empathic and Compassionate Behavior** 3.1 Introduction to Empathy and Compassion-Definition and Key Differences, Emotional Intelligence, and its role in empathy 3.2 Building blocks of empathy – active listening, Perspective-Taking, emotional cues 3.3 Key stages of compassion development in humans, compassion Quotient 3.4 Balance between Compassion and Empathy 3.5 Identification of activities in one's own area of work and related ethical and unethical behaviour, Ethical boundaries, Ethical Conflicts	**CO3**

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

One problem is to allocate to each student. More such problems as mentioned below can be included by the teacher

i. Literature review on the psychology behind ethical and non-ethical behaviour

ii. Analysis of the ethical dilemma situation (such as the Ethical dilemma faced by engineers when they discover a design flaw or safety risk that a company is unwilling to address).

Note: Depending on the requirement of each laboratory experience, micro project and research-based problems, the performance may be conducted in online/offline mode and accordingly appropriate assessment tools may be used.

L) Suggested Term Work (TW):

a. Assignment(s): Preparing a report, critique, undertaking discussion in groups after reading books related to values and ethics/Epics/ Daily newspapers and (Any one)

b. Activities: Group discussion, panel discussion, role play, case study, skits related to issues on values and ethics in the profession and day-to-day life. (These can be instructional strategies for the course, and can be specified clearly)

c. Micro Projects: Development of skits and performance, poster making,

d. Other (Any one Topic)

Suggested Seminar/ Debates on topics such as:

- Charters of professions
- Importance of values and ethics in the identified profession
- Issues of ethical conflicts
- Identified issues from scripts such as the Chanakya Neeti, Kabir ke Dohe etc.
- Lessons on ethics from religious scriptures
- Nonviolent communication for good work culture
- Compassion measurement at workplace
- Issued based on happenings reported in daily news

Teacher can suggest supporting material for reference and preparation.

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

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. 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. To ensure learning, research-based problems may be designed and implemented.

O) Major Equipment, Tools and Software for Laboratory and Research Work: (Not Applicable)

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Professional Ethics and Human Values	D. R. Kiran	McGraw-Hill Education Pvt. Ltd. 2007 ISBN: 9780070633872
2.	A Textbook on Professional Ethics and Human Values	Dr. R S Nagarajan	New Age International (P) Ltd., Publishers, 2017, ISBN: 8122419380, 9788122419382
3.	Ethics, Integrity and Attitude –Hindi (Paperback) (एथिक्स, सत्यनिष्ठा एवं अभिवृत्ति)	P.D Sharma	Rawat Publications, 2019 ISBN: 978-8131609941
4.	Chanakya - Niti (Sutra Sahit) (Hindi)	Chanakya	Maple Press. 2014 ISBN 978-9350335529
5.	Professional Ethics and Human Values	D. R. Kiran	McGraw-Hill Education Pvt. Ltd. 2007 ISBN: 9780070633872

b) Online Educational Resources (OER):

1) https://tibet.emory.edu/documents/Ozawa-deSilva-CompassionandEthics-FinalPrintVersion-JHSH2012.pdf
2) https://www.surendranathcollege.ac.in/wp-content/uploads/2024/02/7.1.9.-HUMAN-VALUES-AND-PROFESSIONAL-ETHICS.pdf
3) https://harmoniouscosmos.com/the-role-of-compassion-in-ethical-decision-making/
4) https://www.uhv.org.in/uhve
5) https://www.kaggle.com/rohankayan/years-of-experience-and-salary-dataset
6) http://gandhismriti.gov.in/sites/default/files/Nonviolent%20Communication%20Elements%20and%20Applications%20%281%29.pdf

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A)	**Course Title:** Financial Literacy	Deemed to be University under Distinct Category
B)	**Course Code:** NEP04	
C)	**Pre- requisite (s):**	

D) **Rationale:** Financial literacy is a critical life skill that everyone should have, yet many people struggle with it. This course explores the fundamentals of financial literacy, including budgeting, saving, investing, and debt management. The students will learn the fundamental principles of budgeting, saving, and investing, along with understanding the key factors that can impact the financial decisions.it communicates the different investment options and the risk-return trade-offs. It also can create a diversified portfolio that fits your risk tolerance and investment goals. In addition to investment strategies, this course covers topics such as credit and debt management, retirement planning, taxes, and insurance.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following industry expected course outcomes by the learners.

Course Outcomes (COs)	Course Outcome Statements
NEP04.CO1	Formulate the investment plan for various situation of income & expenditure of individuals.
NEP04.CO2	Identify various Investment Options for Retirement.
NEP04CO3	Apply Tax-Effective Investment Decisions for various situations.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)				
	PO-1 Apply knowledge of management theories and practices to solve business problems.	**PO-2** Foster Analytical and critical thinking abilities for data-based decision-making.	**PO-3** Ability to develop Value based Leadership ability.	**PO-4** Ability to understand, analyze and communicate global, economic, legal, and ethical aspects of business.	**PO-5** Ability to lead themselves and others in the achievement of organizational goals, contributing effectively to a team environment.
NEP04.CO1	1	-	1	-	-
NEP04.CO2	1	1	1	-	-
NEP04CO3	1	-	1	-	-

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
NEP04	NEP	Financial Literacy	15	-	-	15	30	01	25	-	25	-	-	-	50

H) Course Curriculum Detailing: For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP 2020, unique features like green skills, multidisciplinary aspects, societal connect, IKS, renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Explain the Personal Financial Goals for the given situation. *TSO 1b.* Explain Income/ Expenses/ Net Worth for the given situation. *TSO 1c.* Explain the steps of Budgeting for the	**Unit-1.0: Basic Financial Concepts** 1.1 Personal Financial Goals 1.2 Income, Expenses, and Net Worth	**CO1, CO2**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
given situation. *TSO 1d.* Explain the Cash Flow Management process for the given situation. *TSO 1e.* Explain Saving for household for the given situation. *TSO 1f.* Formulate the investment plan for the given individual. *TSO 1g.* Explain Inflation in the economy *TSO 1h.* Identify the factors effecting the Interest Rates in the economy for the given situation. *TSO 1i.* Explain the role of Bank Accounts in personal savings for the given situation. *TSO 1j.* Explain the Payment Methods. *TSO 1k.* Explain the Credit Management system for the given situation. *TSO 1l.* Explain Debt Management for the given situation. *TSO 1m.* Explain the Insurance plan for the given situation. *TSO 1n.* Formulate the investment plan for the given situation of income & expenditure of individuals.	1.3 Budgeting & Cash Flow Management 1.4 Saving 1.5 Investing 1.6 Inflation & Interest Rates 1.7 Bank Accounts and Payment Methods 1.8 Credit Management 1.9 Debt Management 1.10 Insurance	
TSO 2a. Identify the various the Investment option and types for the given situation. *TSO 2b.* Building a Diversified Portfolio applying risk-return trade-off for the given situation. *TSO 2c.* Apply the Risk-Return Trade-off for the given situation. *TSO 2d.* Explain Informed Investment Decisions for the given situation. *TSO 2e.* Write the steps in Retirement Planning for the given situation. *TSO 2f.* Explain Social Security and Pensions for the given situation. *TSO 2g.* Identify the Investment Options for Retirement Savings for the given situation. *TSO 2h.* Make Plans for Unexpected Events for the given situation. *TSO 2i.* List the Filing Taxes and Forms *TSO 2j.* Outline the Tax Laws and Regulations. *TSO 2k.* Minimizing Tax Liability for the given situation. *TSO 2l.* Make Tax-Effective Investment	**Unit-2.0: Investing & Taxation** 2.1 Investment option and types 2.2 Building a Diversified Portfolio 2.3 Risk-Return Trade-off 2.4 Informed Investment Decisions 2.5 Retirement Planning 2.6 Social Security and Pensions 2.7 Estimating Future Retirement Expenses 2.8 Planning for a Comfortable Retirement 2.9 Investment Options for Retirement Savings 2.10 Planning for Unexpected Events 2.11 Filing Taxes and Forms 2.12 Tax Laws and Regulations 2.13 Minimizing Tax Liability 2.14 Making Tax-Effective Investment Decisions	**CO2**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
Decisions for the given situation.		
TSO 3a. Explain the importance of Entrepreneurship education *TSO 3b.* Outline the Entrepreneurial Opportunities for the given product. *TSO 3c.* Outline the Entrepreneurship Support Eco-System *TSO 3d.* Identify the Business opportunities for the given situation. *TSO 3e.* Identify the steps in market survey for an enterprise. *TSO 3f.* Identify the Procedure and formalities for Bank Finance for the given situation	**Unit-3.0: Entrepreneurship Support System** 3.1 Entrepreneurship education 3.2 Achievement Motivation 3.3 Entrepreneurial Opportunities 3.4 Entrepreneurship Support Eco-System 3.5 Business opportunities Identification 3.6 Market Survey 3.7 Procedure and formalities for Bank Finance	**CO3**

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

Note: Depending on the requirement of each laboratory experience, micro project and research-based problems, the performance may be conducted in online/offline mode and accordingly appropriate assessment tools may be used.

L) Suggested Term Work (TW):

a. Assignment(s):

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

b. Visits:

- Arrange a visit to a tax filing consultancy nearby.

c. Group discussions on current print articles.

- Personal finance
- Taxation over last decade
- Essentials awareness for IT slabs.

d. Self-learning topics:

- Cash Management System for firms.
- Accounts receivable for firms.

e. Micro Projects: Suggested list of course wise micro projects are mentioned herewith

- Analysis of Situations where special provisions for saving has been observed
- Role of Media in Spreading Awareness regarding Tax filing.

f. Seminar Topics:

- The Evolution of the Indian Constitution: From the British Raj to Independence
- Filling Income tax as per Indian Provisions.
- Planning for retirement.

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

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. 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. To ensure learning, research-based problems may be designed and implemented.

O) Major Equipment, Tools and Software for Laboratory and Research Work: (Not Applicable)

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Exploring Financial Literacy	Judi Deatherage M. D	Goodheart-Willcox , ISBN-13: 9781635637069
2.	The Money Guide by	Anushka Rathod	Zebralearn Pvt Ltd, ISBN-13: 978-8196373566
3.	Money Works: The Guide to Financial Literacy	Abhijeet Kolapkar	Publisher Penguin Business, ISBN-13: 978-0143461647
4.	Financial Literacy	Prof. Rajni and Dr. Abhishek Kumar Singh	JSR Publishing House LLP
5.	Taxmann's Financial Literacy – Equip Yourself with The Knowledge and Skills to Achieve Financial Independence and Make Informed Financial Decisions Confidently	Prof. (Dr.) Amit Kumar Singh	Taxmann Publications Private Limited; ISBN-13 : 978-9357785464
6.	Personal Finance: A Treatise on Financial Literacy	Prof (Dr.) Kana Sukumaran	Notion Press, ISBN-13: 979-8894463421
7.	The Legacy of Financial Literacy: Guiding My Child to Financial Success	Jyotinath Ganguly	Notion Press, ISBN-13: 978-1637453223

b) Online Educational Resources (OER):

1) https://www.investopedia.com/guide-to-financial-literacy-4800530#:~:text=Financial%20literacy%20is%20the%20ability%20to%20understand%20and,money%2C%20compound%20interest%2C%20managing%20debt%2C%20and%20financial%20planning.
2) https://www.fidelity.com/learning-center/smart-money/financial-literacy
3) https://www.forbes.com/sites/truetamplin/2023/09/21/financial-literacy--meaning-components-benefits--strategies/
4) https://yourstory.com/2023/07/financial-literacy-is-key-to-unlocking-india-economy
5) https://www.investopedia.com/financial-literacy-5224001

Q) Course Curriculum Developer

S. No.	Name	E-mail Address
1.	Prof. Roli Pradhan	rpradhan@nitttrbpl.ac.in

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A)	**Course Title:** Engineering Economics	Deemed to be University under Distinct Category
B)	**Course Code:** NEP05	
C)	**Pre- requisite (s):**	

D) **Rationale:** The need of engineering economy is primarily motivated by the fact that everything in engineering has to be carried out economically and optimally - whether designing an equipment, choosing between alternatives, operating a plant, marketing a product or maintaining a plant, all of which involve a decision-making process. The decision-making process involves the fundamental elements of cash flows of money, time, and interest rates. This course introduces the basic concepts and terminology necessary for an engineer to combine these three essential elements to solve problems that will lead to better decisions.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following industry expected course outcomes by the learners.

Course Outcomes (COs)	Course Outcome Statements
NEP05.CO1	Apply the laws of economics for various situations.
NEP05.CO2	Evaluate the various engineering project w.r.t. Present worth method, Future worth method, Net present value method, internal rate of return method, Cost-benefit analysis in public projects
NEP05.CO3	Prepare cost sheets for the various products.

F) **Suggested Course Articulation Matrix (CAM):**

Course Outcomes (COs)	Programme Outcomes (POs)				
	PO-1 Apply knowledge of management theories and practices to solve business problems.	**PO-2** Foster Analytical and critical thinking abilities for data-based decision-making.	**PO-3** Ability to develop Value based Leadership ability.	**PO-4** Ability to understand, analyze and communicate global, economic, legal, and ethical aspects of business.	**PO-5** Ability to lead themselves and others in the achievement of organizational goals, contributing effectively to a team environment.
NEP05.CO1	1	-	1	-	-
NEP05.CO2	1	1	1	-	-
NEP05.CO3	1	-	1	-	-

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
NEP05	NEP	Engineering Economics	15	-	-	15	30	01	25	-	25	-	-	-	50

H) Course Curriculum Detailing: For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP 2020, unique features like green skills, multidisciplinary aspects, societal connect, IKS, renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Outline the scope of Engineering Economics. *TSO 1b.* Explain micro & macro-economics. *TSO 1c.* Explain the Theory of demand *TSO 1d.* Explain the demand function for the given situation. *TSO 1e.* List the exceptions of Law of Demand. *TSO 1f.* Explain the Elasticity of demand. *TSO 1g.* Explain the elasticity of demand for the given product. *TSO 1h.* Explain the Laws of variable proportions for the given situation. *TSO 1i.* Explain the Law of returns to scale. *TSO 1j.* Apply the relevant laws of economics for the given situation.	**Unit-1.0 Basic Economics Concepts** 1.1 Engineering Economics – Nature and scope 1.2 General concepts on micro & macro-economics. 1.3 The Theory of demand: Demand function, Law of demand and its exceptions, 1.4 Elasticity of demand, Law of supply and elasticity of supply. 1.5 Theory of production: Law of variable proportion, Law of returns to scale	**CO1**
TSO 2a. Identify the factors in Time value of money. *TSO 2b.* Explain the Principle of economic equivalence *TSO 2c.* Identify the methods of evaluation of engineering projects. *TSO 2d.* Calculate the Net present value method, internal rate of return method, Cost-benefit analysis for the given product	**Unit-2.0: Time Value of Money** 2.1 Time value of money: Simple and compound interest, Cash flow diagram, Principle of economic equivalence. 2.2 Evaluation of engineering projects: Present worth method, Future worth method, Net present value method,	**CO2**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 2e. Explain Depreciation. *TSO 2f.* Distinguish the methods of depreciation. *TSO 2g.* Evaluate the given engineering project w.r.t. Present worth method, Future worth method, Net present value method, internal rate of return method, Cost-benefit analysis in public projects	internal rate of return method, Cost-benefit analysis in public projects. 2.3 Depreciation: Meaning Causes, Factors affecting depreciation, Methods of providing depreciation, Straight Line Method & Diminishing Balance Method	
TSO 3a. List the elements of costs. *TSO 3b.* Differentiate between fixed and variable costs *TSO 3c.* Explain BEP for the given product. *TSO 3d.* Calculate BEP for the given situation. *TSO 3e.* Explain the characteristic of the Indian banking system. *TSO 3f.* Explain the functions of commercial banks. *TSO 3g.* Explain the functions of Reserve Bank of India. *TSO 3h.* Outline the Indian Financial System. *TSO 3i.* Prepare a cost sheet for the given product.	**Unit-3.0: Cost and Banking Concepts** 3.1 Cost concepts: Elements of costs, Preparation of cost sheet, Segregation of costs into fixed and variable costs. Break-even analysis (Simple numerical problems to be solved) 3.2 Indian Banking System: Banks: Meaning, nature, characteristic of the Indian banking system, functions of commercial banks, functions of Reserve Bank of India, Overview of Indian Financial System.	**CO3**

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

a. Cost-Benefit Analysis of Green Technologies

- Problem: How can cost-benefit analysis be used to justify investments in sustainable and green technologies in industries?
- Focus: Evaluation of long-term economic benefits vs. initial investment costs of green technologies such as solar power, energy-efficient systems, and eco-friendly materials.

b. Optimization of Project Scheduling Using Economic Principles

- Problem: How can engineering economic principles be applied to optimize project timelines while minimizing costs?
- Focus: Investigating the economic impact of scheduling delays and exploring methods like Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT).

c. Economic Viability of Renewable Energy Systems

- Problem: What is the economic feasibility of replacing traditional energy sources with renewable energy in large-scale projects?
- Focus: Cost analysis of renewable energy sources like wind, solar, and hydropower and their integration into existing infrastructures.

d. Risk and Uncertainty in Engineering Investment Decisions

- Problem**:** How can risk analysis techniques help improve investment decision-making in engineering projects?

- Focus: Exploring methods to quantify risk and uncertainty, such as Monte Carlo simulations or sensitivity analysis, and their application in engineering economics.

e. Economic Impact of Automation in Manufacturing

- Problem: What are the long-term economic effects of implementing automation in manufacturing processes?
- Focus: Investigating cost reduction, labor displacement, and productivity increases due to automation, and analyzing the return on investment (ROI).

f. Capital Budgeting and Infrastructure Development

- Problem: How can engineering economic models be used to evaluate large-scale infrastructure projects like bridges, highways, or airports?
- Focus: Applying techniques like Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period for evaluating capital expenditures in public infrastructure.

g. Lifecycle Costing in Engineering Design

- Problem: How can lifecycle costing be integrated into the design phase of engineering projects to improve long-term financial outcomes?
- Focus: Assessing the total cost of ownership (TCO) of systems or products from conception to disposal and its impact on engineering decisions.

h. Sustainability vs. Profitability in Engineering Projects

- Problem: How can sustainability practices be balanced with profitability in engineering project management?
- Focus: Analyzing the trade-offs between short-term profits and long-term sustainability goals, and finding ways to integrate them economically.

i. Impact of Inflation on Engineering Project Costs

- Problem: What is the effect of inflation on the cost estimation and budgeting of long-term engineering projects?
- Focus: Developing models to predict and mitigate inflation's impact on project finances and exploring strategies to safeguard against cost overruns.

j. Economic Analysis of Infrastructure Resilience

- Problem: How can economic models be used to assess the cost-effectiveness of building resilient infrastructure in the face of climate change or natural disasters?
- Focus: Cost-benefit analysis of resilient infrastructure investments, including disaster recovery costs and insurance savings.

k. Evaluating Engineering Project Feasibility Using Real Options Theory

- Problem: How can real options theory be applied to evaluate the feasibility and flexibility of engineering projects under uncertainty?
- Focus: Investigating how real options, such as delaying or expanding projects, can be modeled to improve decision-making in uncertain environments.

l. Public-Private Partnerships in Engineering: Economic Considerations

- Problem: What are the key economic challenges and benefits of public-private partnerships (PPP) in engineering infrastructure projects?
- Focus: Exploring the economic models that can be used to balance risks, rewards, and resource allocation between public and private sectors.

Note: Depending on the requirement of each laboratory experience, micro project and research-based problems, the performance may be conducted in online/offline mode and accordingly appropriate assessment tools may be used.

L) Suggested Term Work (TW):

a. Assignment(s):

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

i. Time Value of Money (TVM) Calculations

- Assignment: Explain and apply the concept of the time value of money. Calculate the future value and present value of different cash flows using different interest rates. Analyze how inflation impacts these calculations.
- Objective: Understand and apply TVM concepts to real-world investment decisions.

ii. Cost-Benefit Analysis for a New Engineering Project

- Assignment: Perform a cost-benefit analysis for a hypothetical or real-world engineering project (e.g., construction of a bridge, solar power plant, or water treatment facility). Identify all potential costs and benefits, and calculate the net benefit.
- Objective: Apply cost-benefit analysis techniques to evaluate the feasibility of engineering projects.

iii. Break-even Analysis in Manufacturing

- Assignment: Conduct a break-even analysis for a manufacturing process. Identify fixed and variable costs, and determine the break-even point. Create different scenarios by changing costs and price points.
- Objective: Learn how to determine profitability thresholds and manage operational costs in manufacturing.

iv. Capital Budgeting for Infrastructure Projects

- Assignment: Using techniques like Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period, evaluate a proposed infrastructure project (e.g., road construction, airport expansion). Analyze the financial viability and make a recommendation.
- Objective: Apply capital budgeting techniques to large-scale engineering projects.

v. Depreciation Methods and Their Impact on Project Economics

- Assignment: Explore various depreciation methods (e.g., straight-line, declining balance, sum-of-years-digits) and apply them to engineering assets (e.g., machinery, vehicles). Analyze how different methods affect tax savings and project economics.

- Objective: Understand how depreciation impacts financial decision-making and project budgeting.

vi. Life-Cycle Cost Analysis of Engineering Equipment

- Assignment: Perform a life-cycle cost (LCC) analysis for an engineering system or equipment (e.g., HVAC system, machinery). Consider initial costs, operation, maintenance, and disposal. Compare two alternatives based on LCC.
- Objective: Assess the total cost of ownership of engineering systems from inception to disposal.

vii. Sensitivity Analysis for an Engineering Project

- Assignment: Perform a sensitivity analysis on an engineering project's financial model. Identify critical variables (e.g., cost of materials, labor rates, interest rates) and assess how changes in these variables affect the project's profitability.
- Objective: Learn how to account for uncertainty and variability in project costs and decision-making.

viii. Inflation and Its Impact on Long-Term Engineering Projects

- Assignment: Analyze the impact of inflation on long-term engineering projects, such as power plants or public infrastructure. Calculate how inflation rates affect future costs and overall project budgets.
- Objective: Understand how inflation impacts project budgeting and long-term financial planning.

ix. Economic Analysis of Renewable Energy Projects

- Assignment: Evaluate the economic feasibility of a renewable energy project (e.g., wind farm, solar energy plant) by calculating the return on investment, break-even point, and long-term financial benefits.
- Objective: Learn how to assess the financial viability of sustainable engineering solutions.

x. Risk and Uncertainty in Investment Decisions

- Assignment: Analyze a case study of an engineering project where risk and uncertainty played a significant role. Use probabilistic methods, such as Monte Carlo simulations or decision trees, to model the impact of uncertainty on project outcomes.
- Objective: Develop skills in managing risk and uncertainty in engineering economics.

xi. Public-Private Partnership (PPP) Analysis

- Assignment: Analyze a public-private partnership (PPP) project in engineering (e.g., highway construction or airport management). Assess the risk-sharing model, economic benefits, and potential challenges from both public and private perspectives.
- Objective: Explore the economic considerations and challenges in engineering projects involving multiple stakeholders.

xii. Inventory Management and Economic Order Quantity (EOQ)

- Assignment: Apply the Economic Order Quantity (EOQ) model to an engineering firm's inventory management system. Calculate EOQ and analyze the trade-off between ordering costs and holding costs.

- Objective: Understand the principles of efficient inventory management in engineering operations.

xiii. Feasibility Study of Automation in a Production Line

- Assignment: Conduct a financial feasibility study to assess the benefits and costs of automating a manufacturing production line. Consider factors such as labor cost savings, capital costs, and operational efficiency.
- Objective: Assess the economic impact of automation in engineering.

xiv. Engineering Project Financing

- Assignment: Explore different financing options available for large engineering projects (e.g., project loans, bonds, equity). Analyze the pros and cons of each financing option and their impact on project cost and risk.
- Objective: Understand how financial structures affect the economics of engineering projects.

xv. Ethical and Economic Considerations in Engineering Projects

- Assignment: Analyze an engineering project with significant ethical and economic implications (e.g., building in environmentally sensitive areas, projects affecting communities). Explore the balance between economic benefits and ethical responsibility.
- Objective: Learn to integrate ethical considerations with economic decision-making in engineering projects.

b. Seminar Topics:

- Time Value of Money in Engineering Projects
- Cost-Benefit Analysis in Large Infrastructure Projects
- Depreciation Methods and Their Impact on Engineering Economics
- Economic Feasibility of Renewable Energy Projects
- Break-even Analysis in Engineering and Manufacturing
- Capital Budgeting Techniques in Engineering
- Risk and Uncertainty in Engineering Economic Decisions
- Lifecycle Costing in Engineering Systems
- Public-Private Partnerships (PPP) in Engineering Projects
- Sustainability and Economic Viability in Engineering
- Economic Order Quantity (EOQ) and Inventory Management
- Impact of Inflation on Engineering Projects
- Automation and Its Economic Impact on Manufacturing
- Economic Impact of Lean Manufacturing
- Financing Large-Scale Engineering Projects
- Feasibility Studies for Engineering Projects
- Economic Implications of Engineering Ethics
- Supply Chain Economics in Engineering
- Real Options in Engineering Project Evaluation
- Economic Evaluation of Disaster-Resilient Infrastructure

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

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. 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. To ensure learning, research-based problems may be designed and implemented.

O) Major Equipment, Tools and Software for Laboratory and Research Work: (Not Applicable)

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Engineering Economics	Riggs, Bedworth and Randhwa	McGraw Hill Education India, ISBN: 9780079122483
2.	Principles of Economics	D.M. Mithani	Himalaya Publishing House, ISBN:978-93-5202-762-0
3.	Engineering Economics & Costing	Sasmita Mishra	PHI Learning Pvt. Ltd, ISBN: 9788120341678
4.	Engineering Economy	Sullivan and Wicks	Pearson Hall, ISBN: 9780132554909
5.	Engineering Economics	R.Paneer Seelvan	Prentice-Hall of India Pvt. Ltd, ISBN: 788120348370
6.	Managerial Economics	Gupta G	McGraw Hill Education, ISBN-13:978-0071067867
7.	Cost Accounting: Text, Problems and Cases	Jawahar Lal , Seema Srivastav , Manisha Singh	McGraw-Hill. ISBN-13: 978-9353168384

b) Online Educational Resources (OER):

1) http://courseware.cutm.ac.in/courses/engineering-economics-and-costing/
2) https://ep.jhu.edu/courses/715641-engineering-economics/
3) https://online.stanford.edu/courses/cee146s-engineering-economics-and-sustainability
4) https://ocw.mit.edu/courses/10-490-integrated-chemical-engineering-i-fall-2006/98288885a32c8a4054460082cb87a426_eng_econ_lecture.pdf
5) https://engineering.purdue.edu/online/courses/engineering-economic-analysis

Q) Course Curriculum Developer

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Course Curriculum Detailing- Offline Spell -2

A)	**Course Title:** Advanced Microcontrollers	Deemed to be University under Distinct Category
B)	**Course Code:** VMEL05	
C)	**Pre- requisite (s):**	

D) **Rationale:** Microcontroller is the heart of most of the domestic, industrial, consumable and other high-end electronic products. In every field automation is employed, where microcontroller is an inbuilt element, thus requiring its' knowledge to be vital. This course deals with Advanced Microcontrollers which are used to develop and design embedded systems having low cost, low energy consumption with limited memory and having real time response. It will enable learners to understand the architecture and develop programming skills of ARM Controller in 'C' and in Assembly Language. The learners would also be able to develop simple applications by interfacing various sensor and actuators with the ARM controller.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following industry expected course outcomes by the learners.

Course Outcomes (COs)	Course Outcome Statements
VMEL05.CO1	Analyze microcontrollers architecture, programming and interfacing for various applications.
VMEL05.CO2	Interpret the architecture and operation of ARM Microcontroller.
VMEL05.CO3	Analyze execution of instructions and simple programs for ARM Microcontroller for the specified operations.
VMEL05.CO4	Develop programs written in C and assembly to execute on ARM platform.
VMEL05.CO5	Apply the advanced concepts of Interfacing, AI and system design using ARM Microcontrollers with real-time constraints.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)			
	PO-1 An ability to independently carry out research /investigation and development work to solve practical problems.	**PO-2** An ability to write and present a substantial technical report/document.	**PO-3** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program	**PO-4** Develop semiconductor package using design tools
VMEL05.CO1	3	2	3	-
VMEL05.CO2	2	2	3	-
VMEL05.CO3	3	2	3	-
VMEL05.CO4	3	2	3	-
VMEL05.CO5	3	2	3	2

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		Total Marks (TA+TWA+LA)
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
VMEL05	PCC	Advanced Microcontrollers	45	15	45	15	120	04	30	70	20	-	20	30	170

H) Course Curriculum Detailing: For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP 2020, unique features like green skills, multidisciplinary aspects, societal connect, IKS, renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Describe the basics of RISC machine and CISC machine. *TSO 1b.* Describe the architectures of 8051. *TSO 1c.* Develop Assembly program applying Digital logic and mathematics using 8051. *TSO 1d.* Explain the approach to use LED, ADC, Sensors, LCD, DAC, Serial Communication for applications.	**Unit-1.0 Microcontroller Overview** 1.1 Microprocessors Vs. Microcontrollers, Microcontroller architectures (RISC, CISC), memory architecture, ISA; Little Endian Vs Big Endian 1.2 8051 Architecture and Instruction set 1.3 Programming in C & Assembly for 8051– Interrupts, Timers and Ports 1.4 Interfacing: LED, ADC, Sensors, LCD, DAC, Serial Communication	**CO1**
TSO 2a. Describe the architectures of ARM Controllers. *TSO 2b.* Identify the importance of ARM *TSO 2c.* Interpret the addressing and operating modes of ARM Processor. *TSO 2d.* Develop Assembly Language Program ALP for ARM and ARM peripherals. *TSO 2e.* Develop ALP with minimum instructions and memory. *TSO 2f.* Analyze the given program in terms of code size and computational time.	**Unit-2.0 ARM Controller Basics and Architecture** 2.1 The Acorn RISC Machine, Evolution of ARM architecture, States [ARM, Thumb, Jazelle]; Registers, Modes; Conditional Execution; Pipelining; Vector Tables; Exception handling. 2.2 Cortex M3 Processor architecture, registers and flags, operation modes, memory map, Nested Vector Interrupt Controller, power management 2.3 The ARM Programmer's model, ARM development tools 2.4 Program Counter and Program ROM Space in ARM, Viewing Registers and Memory with ARM Keil IDE	**CO2**
TSO 3a. Interpret the addressing and operating modes of ARM processor. *TSO 3b.* Develop ARM assembly language programs using data transfer instructions, arithmetic instructions and logical instructions. *TSO 3c.* Develop ARM assembly language programs based on looping, counting and indexing concept. *TSO 3d.* Articulate the concept behind embedded C programming.	**Unit-3.0 ARM Basic Assembly Language Programming** 3.1 Instruction classification and format, Addressing modes, Data transfer instructions, Arithmetic instruction, Logical group of instructions 3.2 ARM Assembly Programming, Assembling an ARM Program 3.3 ARM Programming using C**:** Overview of C compilers and Optimization, Basic 'C' data types, C looping Structures, Register Allocation	**CO3**
TSO 5a. Analyze the use of Branch, Call and Looping Instructions in ARM. *TSO 5b.* Interpret the use of THUMB instruction set. *TSO 5c.* Describe the pipeline stages of the ARM, and the pipeline operations that take place at each stage.	**Unit-4.0 ARM Advanced Assembly Language Programming** 4.1 Branch, Call and Looping in ARM: Looping and Branch Instructions, Calling Subroutine with BL, ARM Time Delay and Instruction Pipeline, Conditional Execution	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 5d. Compare the architecture and applications of ARM Cortex M – A & R series.	4.2 THUMB Instruction Set 4.3 Basic ARM Assembly Language Programs, Pipelining in ARM 4.4 ARM Cortex M, A and R series	
TSO 5a. Describe the concepts related with interfacing memory and peripherals with embedded systems. *TSO 5b.* Analyze the procedure related with interfacing microcontroller development board with various sensors for a given application/problem and display devices for a given application. *TSO 5c.* Describe the use of Artificial Intelligence in microcontrollers. *TSO 5d.* Analyze the use of ARM for real time applications. *TSO 5e.* Explain strategies to implement real-time AI applications on ARM microcontrollers.	**Unit-5.0 Interfacing and Real time operation** 5.1 Architecture of LPC214X, Memory Addressing, IO ports, Timers/counter, Watch Dog Timer, PWM, ADC/DAC, UART, Interrupts, Displays, 5.2 C programming 5.3 Interfacing memory and I/O devices with ARM using embedded C programming: Keyboard, servo motor, stepper motor, sensors, ADC/DAC, display devices 5.4 Artificial Intelligence in microcontrollers 5.5 Real time operation	**CO5**

J) Suggested Laboratory Experiences:

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
Part A (At least 6 experiments are mandatory)			
LSO 1.1 Analyse features of ARM Microcontroller development kit with comparison to 8051 development kit. *LSO 1.2* Analyse the datasheet of the ARM microcontroller in the kit to identify its CPU, memory, I/O ports, and timers/counters.	1.	Analysis of ARM and 8051 development kit	CO1, CO2
LSO 2.1 Test the output of assembly language programs based on data transfer instructions.	2.	ALP based on data transfer instructions	CO1, CO3
LSO 3.1 Test the output of developed assembly language programs based on arithmetic instructions (e.g. 8-bit addition, subtraction, multiplication, division).	3.	ALP based on arithmetic instructions	CO1, CO3
LSO 4.1 Test the output of developed assembly language programs based on logical instructions (and, or etc.).	4.	ALP based on logical instructions	CO1, CO3

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
Part A (At least 6 experiments are mandatory)			
LSO 5.1. Test the output of developed assembly language programs based on branch instructions.	5.	ALP based on branch instructions	CO1, CO3
LSO 6.1. Test the output of developed assembly language programs based on looping, counting and indexing concept.	6.	ALP based on looping, counting and indexing	CO1, CO3
LSO 7.1. Test the output of developed assembly language programs to introduce delay (e.g. 1 ms delay) using timer/counter.	7.	ALP based on timer/counter	CO1, CO3
LSO 8.1 Test the output of developed assembly language programs for interrupts.	8.	ALP based on interrupt handling	CO1, CO3
Part B (At least 6 experiments are mandatory)			
LSO 9.1 Develop Embedded C programs to blink an LED connected to an ARM microcontroller GPIO pin.	9.	Basic embedded C programming for LED blinking	CO3, CO4, CO5
LSO 10.1 Develop Embedded C programs to connect and control multiple LEDs and switches using GPIO pins of the microcontroller.	10.	Digital I/O Interfacing	CO3, CO4, CO5
LSO 11.1 Investigate the principle of Analog-to-Digital conversion and interface analog sensors with ARM microcontroller. *LSO 11.2* Build code to Interface a temperature sensor (e.g., LM35) with the microcontroller and display the temperature readings on an LCD.	11.	Analog-to-Digital Conversion (ADC)	CO3, CO4, CO5
LSO 12.1 Implement serial communication protocols for data exchange between microcontrollers and external devices. *LSO 12.2* Interface two microcontrollers using UART and exchange data between them.	12.	Serial communication protocol implementation	CO3, CO4, CO5
LSO 13.1. Generate pulse width modulation (PWM) signal using microcontroller. *LSO 13.1* Control the speed of a DC motor using PWM signals generated by the microcontroller.	13.	Motor control using PWM signal	CO3, CO4, CO5
LSO 14.1 Build code to Interface an accelerometer sensor and display real-time motion data on an OLED display.	14.	Accelerometers sensor integration with OLED display	CO3, CO4, CO5
LSO 15.1 Build code to control an actuator with LPC 2148 microcontroller for stepper motor control application.	15.	Controlling actuator with LPC 2148 microcontroller	CO3, CO4, CO5

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
Part A (At least 6 experiments are mandatory)			
LSO 16.1 Interface various sensors with the microcontroller and process sensor data. *LSO 16.2* Build embedded C code to interface temperature sensor and humidity sensor with LPC2148 and display on OLED.	16.	Interfacing of temperature sensor and humidity sensor with LPC2148 microcontroller and OLED display	CO3, CO4, CO5
LSO 17.1 Implement a real-time operating system (RTOS) for multitasking and scheduling. *LSO 17.2* Design a simple RTOS-based application with multiple tasks performing independent functions, such as sensor data acquisition and display updating.	17.	Real-Time Operating System (RTOS) Implementation	CO3, CO4, CO5
LSO 18.1 Implement real-time AI applications on ARM microcontrollers.	18.	Real-time AI applications on ARM microcontrollers	CO5

K) Suggested Research Based Problems

i. Implement a Digital Clock and Alarm using ARM microcontroller that needs a keypad to be interfaced with the following requirement. Key 1 to turn on alarm, Key 2 to enable alarm settings, Key 3 to enable time settings, Key 4 to change hour's settings, Key 5 to change minute settings, Key 6 to increment the time, Key 7 to decrement the time. The normal time and alarm time should be displayed using 2 X 16 LCD and a buzzer should be triggered once the normal time equal to alarm time.

ii. Develop an ARM based waste management system. In this, the sensors are placed in the common garbage bins placed at public places. When the garbage reaches the level of the sensor, then that indication will be given to ARM micro-controller. The controller will give an indication to the driver of the garbage collection truck as to which garbage bin is completely filled and needs urgent attention. ARM 7 will give indication by sending SMS using GSM technology.

iii. Design and implement a temperature-controlled greenhouse system using the combination of an ARM Controller and a GSM communications module linked by a serial communications port. Using this, various Parameter values could be efficiently set from the remote location and whenever it crosses the set limit, the ARM processor will send an SMS to a concerned person(s) mobile phone. The concerned person(s) can control the system through the mobile phone by sending message to the system.

iv. Design and implement a remote-controlled robot using microcontroller and sensor integration, actuator control, and real-time operation.

v. Design an ARM based automated patient monitoring system which continuously measures patient parameters such as heart rate and rhythm, respiratory rate, blood pressure and many other parameters has become a common feature of the care of critically ill patients.

vi. Develop an ARM Micro controller-based precision agriculture which includes accessing all-time data about the conditions of the crops, soil and ambient air. Sensors in fields measure the moisture content and temperature of the soil and surrounding air.

vii. Design and implement a smart home automation system.

viii. Design a real-time data acquisition & control system using the ARM Cortex M4 Microcontroller. It is required to periodically monitor and control the temperature in a boiler which ranges from 0°C to 140°C. The temperature has to be kept at a set-point of 60°C ± 5°C. Provision should be given for receiving the set-point value of temperature from the PC.

Note: Depending on the requirement of each laboratory experience, micro project and research-based problems, the performance may be conducted in online/offline mode and accordingly appropriate assessment tools may be used.

L) Suggested Term Work (TW):

a. Assignment(s):

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

i. Explain a generic program status register used in ARM with a detailed description of all fields.
ii. Write the number 2024 in 32-bit binary, binary coded decimal, ASCII and single precision floating point notation.
iii. Describe the addressing and operating modes of ARM Processor.
iv. Compare and contrast ARM, Thumb, and Thumb-2 instruction set architecture in ARM processors.
v. Analyze the usage of the Watchdog timer with suitable examples.
vi. Compare the applications of ARM Cortex M, A & R series.
vii. Write down the steps required to implement an application with the following events in embedded C on Cortex M4 Microcontroller.
viii. Assume that initially both LEDs are OFF and Blue & Green LEDs are connected to Ports PB6 and PB7 respectively.
    - Receive a character sent from PC through USART2.
    - Activate the Green LED upon receiving the character 'A'.
    - Switch OFF Green LED on receiving ‘B’.
    - Activate the Blue LED upon receiving the character 'C'. Switch OFF Blue LED on receiving ‘D’.

b. Seminar Topics:

- Python Libraries and Packages used in data analytics
- PIC Microcontroller Architecture

- Serial Communication Protocols
- Sensors for Microcontroller Applications
- Actuators for Microcontroller Applications
- Modern Display Technology
- Real-time operating systems
- Using neural networks on microcontrollers

M) Suggested Specification Table for End Semester Theory Assessment (ETA): Questions may be designed based on the higher taxonomy level of cognitive domain.

COs	Relevant Unit Number and Title	Marks
CO1	Unit 1.0 Microcontroller Overview	16
CO2	Unit 2.0 ARM Controller Basics and Architecture	18
CO3	Unit 3.0 ARM Basic Assembly Language Programming	12
CO4	Unit 4.0 ARM Advanced Assembly Language Programming	12
CO5	Unit 5.0 Interfacing and Real time operation	12
Total		**70**

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. 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. To ensure learning, research-based problems may be designed and implemented.

O) Major Equipment, Tools and Software for Laboratory and Research Work:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience /Practical Number
1.	Educational Practice Board for ARM7 LPC2148	• LPC2148 microcontroller • 60Mhz. Max operating speed • 512kB of on-chip flash memory • 32KB of on-chip SRAM + 8KB RAM for USB • 9-volt only operation with supplied AC adapter • On board Power-On LED indication • On board Reset Switch with LED indication • On board Switch for Run/Program mode switching	All

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

		• Two 20 Pin (10x2 header) Connector for total 32 GPIO lines
		• On board USB Connector for UART0 interface with LED indication
		• On board DB9 connector for UART0 interface
		• On board DPDT switch for UART0 connector switching between USB and DB9 connector.
		• On board USB for Flashing
		• On board three pin header for UART1 interface
		• On board MMC/SD card connector available
		• On board fourteen pin (7x2 header) connector for twelve channels On-Chip ADC interface
		• On board three pin header for two channel On-Chip ADC interface
		• On board six pin relimate connector for SPI0 Interface
		• On board six pin relimate connector for SSP Interface
		• On board four pin relimate connector for I2C0 Interface
		• On board four pin relimate connector for I2C1 Interface
		• On board JTAG emulation connector (10x2 pins)
		  • On board two pin relimate connector facility available for on chip DAC output
		  • On board two pin relimate connector facility available for RTC battery interface
		  • On board test points/ Connector facility available for CAP0 and CAP1 peripherals.
		• On board test points/ Connector facility available for Match0 and Match1 peripherals.
		• On board test points/ Connector facility available for PWM interface.
		• On board test points/ Connector facility available for External Interface.
		Test points for Power supply signals	

2.	Advance 8051 Microcontroller Board with JTAG Debugger	C8051 F340 CPU Operating up to 48MHz, 4KB on-chip RAM and 64KB on-chip Flash memory, On board JTAG emulation connector, Universal Serial Bus (USB) Function Controller, High-speed pipelined 8051-compatible microcontroller core, In-system, full-speed, non-intrusive debug interface(on-chip), On chip Universal Serial Bus (USB) Function Controller, True 10-bit 200 KSPS differential / single-ended ADC with analog multiplexer, On-chip Voltage Reference and	1 to 8

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience /Practical Number
		Temperature Sensor, On-chip Two Analog Voltage Comparators, Precision internal calibrated 12 MHz internal oscillator, Internal low-frequency oscillator for additional power Savings, On Chip Programmable Counter/Timer Array (PCA) with five capture/compare modules and Watchdog Timer function, On Chip SMBus/I2C and SPI serial interfaces, On board Data Transfer Interfaces, DB9 connector for UART0 interface, 3 pin header for UART 1 interface, On board Functionalities, JTAG emulation connector, Reset and Run/Program mode (Boot Mode Selection) switch, Two 20-pin FRC Connector for 32 Port 1/0 (5 V tolerant), Two user LEDs, Flash Programming using USB port, Integrated development software, Mechanical Parameters: Size-55mm X 110mm, Input Voltage - 9V DC, JTAG Emulator for Real time debugging.	
3.	Kiel Software	Keil MDK v6, MDK-ARM v5. xx	All
4.	Proteus VSM (Virtual System Modelling) Software	Proteus Simulation Software with following Microcontroller Models: - • 8051 • Arduino AVR • PIC 16 • Proteus VSM for ARM 7/ LPC 2000 Advanced Simulation Features	All
5.	Electronics Hardware Items	Arduino Uno, Raspberry Pi, Arduino Mega, Arduino Shield	9 to 13
6.	All in One general Purpose Board	To interface basic GPIO components to the controller • On board display options including 8 LED, 16x2 character LCD (Operating in 4-bit or 8-bir mode), 2 digit 7-segment display • Switches including four general purpose keys to provide digital input to GPIO pins of microcontroller • Two-by-two matrix keyboard • I2C and SPI based EEPROMs for protocol demonstration experiments • Stepper motor interface with built-in H-bridge driver IC • DC motor interface • 1 Relay output • Facility to provide 2 channel ADC in put using potentiometer and unity gain amplifier for protection	9 to 18

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience /Practical Number
		• On board buzzer to generate various frequencies Compatible with different educational practice boards	
7.	Microcontroller development Boards	STM32F401 Nucelo board	9 to 17
8.	Interfacing Boards	Stepper Motor, DC Motor, ADC, DAC, LCD, Keyboard	12,14, 16,17
9.	*GSM Modem with enclosure*	• GSM modem with serial communication interface • Standard RS-232 interface using 9 pin D connector provided with the device for communication • Controlling through AT commands. • Modem linked to a PC, micro-controller or DSP based embedded system for sending SMS. Data circuit asynchronous, transparent, and non-transparent up to 14400 bits/s and baud rate of 30 to 115,200 bits/s	13
10.	GLCD/TFT Display Kit	• 3.5-inch MCU/RGB interface • QVA landscape TFT/LCD with touch screen • 320X240 resolution • Viewing area of 70.08mm X 52.56 mm • LED back light • Parallel and serial interface option • Mounted on a base board with thirty-four pin connector for easy connection with EPB1768 Cortex M3 board a) Useful for learning TFT/Touch Screen interface and using it for project and prototype development	15
11.	Function Generator	b) 100MHz Function & Arbitrary Generator,500 MSa/s-DG4102	9 to 18
12.	Digital Oscilloscope	• Analog bandwidth: 100MHz * 2 • Number of channels: 2 channels • Maximum real time sampling rate: 1GSa/s • Vertical sensitivity: 50 mV/div ~ 500 V/div • Horizontal time base range: 50S/div ~ 10nS/div • Maximum test voltage: 40 V (1X probe), 400	9 to 18

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience /Practical Number
		V (10X probe) • Input resistance: 1MΩ • Coupling mode: AC/Direct Current c) Trigger mode: Single, Normal, Auto Trigger edge: Rising edge/Falling edge	
13.	Regulated DC Power Supply	i. Regulated Power Supply 0-30V DC, 0-20 Amp, Input Voltage: AC 220V ±5%, Output voltage:0-30 V, Output current:0-20 Amp, Voltage display: 3½ Digit LED, Current display: 3½ Digit LED	All
14.	Digital IC Tester	• Package: Digital ICs of 14, 16, 18,20,24,28 & 40 pins dual in line • Range: Tristate, Open Collector & Bidirectional TTL/CMOS ICs • Method: Truth table comparison. • Sockets: 20 and 40 pin ZIF • Keyboard: 24 feather touch keys. • Display: 16 digit 0.5" Seven segment LED display • Voltage: 230 volts + 10%, 50Hz, AC ii.	9 to 18
15.	Breadboard	a. MB 102 Breadboard with Power Supply Module, Jumper Wires, Battery Clip,830 & 400 tie-Points	9 to 18
16.	MATLAB software and all toolboxes	b. Campus wide license	All

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition withISBN
1.	ARM Microcontrollers: Theory and Practical Applications	Hung Le	Cognella, Inc, 2021, ISBN: 978-1516585830
2.	The Definitive Guide to ARM® CORTEX®-M3 and CORTEX®-M4 Processors	Joseph Yiu	Newnes, Elsevier, Third Edition, ISBN: 978-9332511484
3.	ARM System Developer's Guide-Designing and Optimising System Software	Andrew N. Sloss, Dominic Symes and Chris Wright	Elsevier, Morgan Kaufman publishers, 2009, ISBN: 978-1558608740
4.	Programming with STM32: Getting Started with the Nucleo Board and C/C++	Donald Norris	McGraw Hill TAB; 2018, ISBN: 978-1260031317
5.	ARM Assembly Language: Fundamentals and Techniques	William Hohl	CRC Press, First Edition, ISBN: 978-1420062081

S. No.	Titles	Author(s)	Publisher and Edition withISBN
6.	Microcontrollers: Theory and Applications	Ajay V. Deshmukh	McGraw Hill Education, 2017, ISBN: 978-0070585959
7.	Microcontroller (ARM) and Embedded System	Raghunandan G.H.	Cengage learning Publication, 2020, ISBN: 978-9353504106
8.	ARM System-on-Chip Architecture	Steve Furber	Pearson, Second Edition, 2016, ISBN: 978-8131708408
9.	Embedded System	Raj Kamal	McGraw Hill; Fourth Edition, 2020, ISBN: 978-9353168025
10.	AI at the Edge: Solving Real-World Problems with Embedded Machine Learning	Daniel Situnayake, Jenny Plunkett	O'Reilly Media, First Edition, 2023, ISBN: 978-1098120207

b) Online Educational Resources (OER):

1) https://www.youtube.com/watch?v=0xgvINDxXJI&list=PLbRMhDVUMngcJu5oUhgpgYqtOn7DmSfuU; Embedded System Design with ARM, IIT Kharagpur July 2018 @
2) https://www.youtube.com/watch?v=tqjXYjrL5w8&list=PLuv3GM6-gsE01L9yDO0e5UhQapkCPGnY3&index=41; Lecture 41: ARM Microprocessors and Microcontrollers – Kharagpur
3) https://docs.python.org/3/tutorial/
4) "The insider's guide to the STM32 ARM based Microcontroller", (www.hitex.com)
5) https://www.st.com/resource/en/programming_manual/pm0214-stm32-cortexm4-mcus-and-mpus-programming-manual-stmicroelectronics.pdf
6) https://www.st.com/resource/en/reference_manual/rm0316-stm32f303xbcde-stm32f303x68-stm32f328x8-stm32f358xc-stm32f398xe-advanced-armbased-mcus-stmicroelectronics.pdf
7) https://onlinecourses.nptel.ac.in/noc20_ee42/preview
8) https://onlinecourses.nptel.ac.in/noc20_ee98/preview
9) https://feng.stafpu.bu.edu.eg/Electrical%20Engineering/2461/crs-12134/Files/E626_RTES_lec03.pdf
10) https://sist.sathyabama.ac.in/sist_coursematerial/uploads/SBMA5201.pdf
11) Note: @ Students are advised to refer NPTEL course of "Embedded system Design with ARM" by Indranil Sengupta & Kamalika Datta and download course (but not limited to) Lecture Nos: 10, 11, 15, 16, 18, 19, 20, 22, 23, 24, 25, 26, 28, 29, 32, 38, 39, 40, 41 for understanding topics given in Sr. No 8 and Sr. No 9. (Link: https://nptel.ac.in/courses/106/105/106105193/)

Q) Course Curriculum Developer

S. No.	Name	E-mail Address
1.	Prof. Susan S. Mathew	ssmathew@nitttrbpl.ac.in

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A)	**Course Title:** Analog and Mixed Signal IC Design	Deemed to be University under Distinct Category
B)	**Course Code:** VMEL06	
C)	**Pre- requisite (s):** Analogue Electronics, Digital Electronics, Circuit Analysis and CAD operations, Introduction to Machine Learning/AI Fundamentals, Python Programming for Engineers	

D) **Rationale:** The course introduces design aspects of dynamic analog circuits and analog-digital interface electronics in CMOS technology, with integrated AI/ML methodologies for optimization, automation, and intelligent design. Students will develop skills to specify, design, and implement ADC & DAC using both traditional methods and AI-driven approaches. This enhanced Mixed Signal IC Design course equips students with essential knowledge to tackle modern IC design challenges using machine learning for circuit optimization, automated design flows, and intelligent performance prediction. By mastering this intersection of disciplines, students will be prepared to contribute to advancements in diverse fields where mixed signal ICs play a pivotal role in enabling innovative technologies.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following industry expected course outcomes by the learners.

Course Outcomes (COs)	Course Outcome Statements
VMEL06.CO1	Analyze Sample and Hold circuits for high/low speed signals and apply ML algorithms for performance optimization and parameter prediction
VMEL06.CO2	Design single and cascaded stage amplifiers using traditional methods and AI-assisted design automation tools
VMEL06.CO3	Optimize ADC and DAC architectures using conventional techniques and machine learning-based performance enhancement
VMEL06.CO4	Analyze CMOS Switched Capacitor Circuits and implement neural network models for circuit behaviour prediction
VMEL06.CO5	Develop mixed-signal circuits using EDA tools and AI/ML frameworks for intelligent design optimization

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)			
	PO-1 An ability to independently carry out research /investigation and development work to solve practical problems.	**PO-2** An ability to write and present a substantial technical report/document.	**PO-3** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program	**PO-4** Develop semiconductor package using design tools
VMEL06.CO1	3	2	3	2
VMEL06.CO2	3	2	2	2
VMEL06.CO3	3	2	2	2
VMEL06.CO4	3	2	3	2
VMEL06.CO5	3	2	3	2

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
VMEL06	PCC	Analog and Mix Signal IC design	45	15	45	15	120	04	30	70	20	-	30	20	170

H) Course Curriculum Detailing: For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP 2020, unique features like green skills, multidisciplinary aspects, societal connect, IKS, renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Explain the effect of under and over sampling with respect to the design rules of mixed IC. *TSO 1b.* Describe the given types of sampling systems and the applications of each type of sampling system. *TSO 1c.* Describe the types of distortion introduced in the sample and hold circuit due to the design parameters. *TSO 1d.* Classify the types of components to be fabricated in the batch process. Design Sample and Hold circuit for the high and low speed circuits	**Unit -1.0 Sampling and Sampling Circuit** 1.1 Introduction to sampling, Spectral properties of sampled signals, Oversampling, Anti-alias filter design. Time Interleaved Sampling, Ping-pong Sampling System, Analysis of offset and gain errors in Time Interleaved Sample and Hold, and comparator. 1.2 Sampling circuits- Distortion due to switch - Charge injection - Thermal noise in a sample and holds - Bottom plate sampling - Gate bootstrapped switch -Nakagome charge pump. Characterizing Sample and Hold - Choice of input frequency 1.3 **Machine learning for sampling rate optimization** 1.4 **AI-driven noise prediction and mitigation** 1.5 **Reinforcement learning for adaptive sampling strategies**	**CO1**
TSO 2a. Describe the small and large signal MOS and BJT model in detail. *TSO 2b.* Explain the need for active and passive mirror for the mixed signal IC design. *TSO 2c.* Compare CS, CG and CD amplifiers in detail. *TSO 2d.* Analyze the different pairs and cascade amplifiers.	**Unit 2.0 Design of Analog IC** 2.1 **Small Signal & large signal Models** of MOS & BJT transistors. Analog MOS Process. 2.2 **Passive & Active Current Mirrors:** Basic current mirrors, Cascode current mirror, Active loads, voltage and current references; 2.3 **Frequency response of integrated circuits:** Single Stage (CS, CG, CD) amplifiers, Cascade Stage; frequency response (miller effect) of CG, CS, CD, Operation of Basic Differential Pair, differential pair with MOS loads, Frequency response of Cascade & Differential Pair 2.4 **Machine learning for transistor model parameter extraction** 2.5 **AI-based circuit synthesis and optimization**	**CO2**
TSO 3a. Describe the fundamental parameters of data converters. *TSO 3b.* Analyze the working of the given type of ADC IC design in detail. *TSO 3c.* Analyze the working of the given type of DAC IC design in detail. *TSO 3d.* Compare the given type of ADC architectures.	**Unit-3.0 ADC and DAC** 3.1 Data converter fundamentals: Offset and gain Error, Linearity errors, Dynamic Characteristics, SQNR, Quantization noise spectrum 3.2 **ADC:-** Flash ADC - Regenerative latch - Preamp offset correction - Preamp Design - necessity of upfront sample and hold for good dynamic	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 3e. Compare the various types of DAC architectures.	performance. Folding ADC - Multiple-Bit Pipeline ADCs and SAR ADC, ADCs, High-speed ADCs, (e.g. flash ADC, pipeline ADC and related architectures), High-resolution ADCs (e.g. delta-sigma converters), 3.3 **DAC:-** DAC spectra and pulse shapes - NRZ vs RZ DACs. DAC Architectures: Binary weighted - Thermometer DAC - Current steering DAC - Current cell design in current steering DAC – Charge Scaling DAC - Pipeline DAC, **Machine learning for ADC/DAC calibration and correction, AI-driven architecture selection and optimization**	
TSO 4a. Describe the working of the delta sigma converter in detail. *TSO 4b.* Explain how excess loops delay recovery. *TSO 4c.* Describe the nonlinear and linear effects on the design parameters of ADC and DAC. *TSO 4d.* Describe the design consideration for switching capacitor. *TSO 4e.* Analyze the charge injection and clock feed through effect.	**Unit-4.0 Oversampling Convertor and Switching Capacitor** 4.1 Benefits of Oversampling -Oversampling with Noise Shaping - Signal and Noise Transfer Functions - First and Second Order Delta-Sigma Converters. Introduction to Continuous-time Delta Sigma Modulators - time-scaling - inherent antialiasing property - Excess Loop Delay - Influence of Op-amp nonidealities - Effect of Op-amp nonidealities - finite gain bandwidth - Effect of ADC and DAC nonidealities - Effect of Clock jitter 4.2 Switched capacitor circuits, design of switched capacitor amplifiers and integrators, effect of opamp finite gain, bandwidth and offset, circuit techniques for reducing effects of opamp imperfections, switches and charge injection and clock feed-through effects. 4.3 **Machine learning for delta-sigma modulator optimization** 4.4 **AI-based switched capacitor circuit synthesis**	**CO4**
TSO 5a. Explain the need for high-speed IC design considerations. *TSO 5b.* Describe the functions of the clock, data recovery circuit, and equalization circuit. *TSO 5c.* Describe the IC packaging design rules with proper examples. *TSO 5d.* Describe the design of high speed receiver architecture.	**Unit-5.0 High Speed Transceiver Circuit** 5.1 Introduction to high-speed wireline communication circuits. Transmitter architectures, and circuits, equalization techniques. Receiver architecture, overview of clock and data recovery circuits, and equalization. 5.2 **AI-based equalization and adaptation** 5.3 **Machine learning for PLL optimization**	**CO5**

J) Suggested Laboratory Experiences:

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
LSO 1.2 Analyse the Anti-Alias circuit.	1.	Design the Anti alias filter for the specific Sampled circuit.	CO1
LSO 2.1. Test the performance of the current mirror circuit.	2.	Design the current mirror circuit.	CO2
LSO 3.1 Test the performance of the high speed sample and hold amplifier circuit.	3.	Design of high speed sample and hold Amplifier	CO2
LSO 4.1. Test the CMOC inverter and Op-Amp circuit performance.	4.	Develop Layout of CMOS a) Inverter b) Opamp & Perform post Layout Simulation	CO2
LSO 5.1. Test the performance of the single and two stage Op-amp.	5.	Design and optimize a Single stage Op-amp, Two stage Op-amp. Design of Band-gap reference Circuit.	CO2
LSO 6.1. Predict the circuit performance as per the given circuit parameters for the given design.	6.	Machine learning for transistor model parameter extraction	CO2
LSO 7.1. Test the performance of the Flash type ADC and measure the design parameters.	7.	Design of Flash ADC.	CO3
LSO 8.1 Test the performance of the current steering DAC and measure the design parameters.	8.	Design of Current – Steering DAC	CO3
LSO 9.1 Analyse the performance of the AI-based ADC calibration.	9.	AI-Assisted ADC Calibration and Correction	CO3
LSO 10.1 Test the performance of the switched capacitor integrator and test the out for the various types of inputs.	10.	Design of Switched Capacitor Integrator	CO4
LSO 11.1 Test the performance of the designed charge pump circuit.	11.	Design of Charge Pump Circuit.	CO4
LSO 12.1 Test the performance of the Flash type ADC and measure the design parameters.	12.	Design of 8-bit Flash ADC and measure its DNL, INL, etc.	CO4
LSO 13.1 Test the performance of the designed high speed transceiver circuit.	13.	Develop a mixed signal High speed transceiver circuit	CO5
LSO 14.1 Develop an optimized layout using deep learning	14.	Deep Learning for Layout Optimisation	CO5
LSO 15.1 Apply the AL&ML for the Mixed System Design Project	15.	AI-Driven Mixed-Signal System Design Project	CO1 to CO5

K) Suggested Research Based Problems

i. Enhancing Power Efficiency and Performance in Analog and Mixed-Signal Integrated Circuits for emerging IoT and AI Applications under Process Variability Constraint.
ii. Increased process variability affecting analog performance metrics like gain, linearity, and noise.
iii. Difficulty in achieving high-frequency operation with ultra-low power consumption.
iv. Integration of high-precision analog blocks with high-speed digital circuits on the same die, leading to noise coupling and design trade-offs.

Note: Depending on the requirement of each laboratory experience, micro project and research-based problems, the performance may be conducted in online/offline mode and accordingly appropriate assessment tools may be used.

L) Suggested Term Work (TW):

a. Assignment(s):

- Traditional Flash ADC design for the 3 and half digit.
- AI-enhanced wireless transmitter optimization.
- ML-based DAC calibration system.
- Neural network for circuit behavior modelling.
- Reinforcement learning for design automation.

b. Micro Projects: - (Sample Title/statements)

- AI-optimized charge pump design
- Smart switched capacitor integrator with ML compensation
- End-to-end ML pipeline for IC design optimization
- Deep learning-based yield prediction system

c. Seminar Topics

- AI/ML Engineer in EDA companies
- Design Automation Specialist
- Mixed-Signal AI Hardware Designer
- Research roles in AI-driven IC design
- Neuromorphic IC design
- AI accelerator architectures
- Quantum-AI hybrid circuits
- Sustainable IC design using AI

d. Self- Learning Topics

- High Speed ADC and DAC circuit design.
- Low-power, high-speed design principles.

- TensorFlow/PyTorch for IC design
- Reinforcement learning in EDA
- Neural network accelerators for analog computing
- AI-driven design automation tools

M) Suggested Specification Table for End Semester Theory Assessment (ETA): Questions may be designed based on the higher taxonomy level of cognitive domain.

COs	Relevant Unit Number and Title	Marks
CO1	Unit-1.0 Sampling and Sampling Circuit	13
CO2	Unit-2.0 Design of Analog IC	15
CO3	Unit-3.0 ADC and DAC	16
CO4	Unit-4.0 Oversampling Convertor and Switching Capacitor	13
CO5	Unit-5.0 High Speed Transceiver Circuit	13
Total		**70**

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. 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. To ensure learning, research-based problems may be designed and implemented.

O) Major Equipment, Tools and Software for Laboratory and Research Work:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience /Practical Number
1.	Computer system	Processor Intel Core i9, 12 GB RAM, 15 GB free disk space	All
2.	Cadence full suit	Cadence academic bundles – Research, • Toolbox for Logic Synthesis, • Toolbox for Physical Design • Toolbox for Physical Verification • Toolbox for Custom Design and Simulation (Virtuoso) • Cadence AMS designer • Industry-standard for designing and simulating mixed-signal circuits.	All

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience /Practical Number
		Includes Spectre for analog simulation and AMS Designer for mixed-signal analysis.	
3.	Synopsys	Synopsys toolbox for Floor Planning • IC Compiler II • Fusion Compiler • Custom Compiler	All
4.	Keysight ADS (Advanced Design System)	• Full research version (RF and mixed-signal circuit design)	All
5.	Mentor Graphics Calibre	• Used for layout versus schematic (LVS), design rule checks (DRC), and parasitic extraction. • Mentor Graphics Questa ADMS.	All
6.	**Magic VLSI** (Open Source)	• Free tool for layout design with basic DRC and extraction.	All
7.	Python, TensorFlow, PyTorch, scikit-learn, Keras, AI tools for VLSI Design	• Free tool programming design with application orientated functions	6-15

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition withISBN
1.	Design Of Analog CMOS Integrated Circuits	Behzad Razavi	Tata Mcgraw Hill,2005.
2.	Analysis & Design of Analog Integrated Circuits	Gray & Meyer	4th edition, Wiley, 2001
3.	CMOS Mixed Signal Circuit Design.	Jacob Baker	John Wiley, IEEE Press, 2nd Edition, 2009
4.	Analog MOS Integrated Circuits	Gray, Wooley, Brodersen	IEEE Press, 1989
5.	Design of Analog Integrated Circuits and Systems	Kenneth R. Laker, Willy M.C. Sansen, William M.C.Sansen	McGraw Hill, Published by McGraw-Hill College, 1994, ISBN 10: 007036060X / ISBN 13: 9780070360600
6.	The Design of CMOS Radio-Frequency Integrated Circuits	Thomas H. Lee	Cambridge University Press, Second Edition, 2004.
7.	Analog-Digital Converters for Industrial Applications	Frank Ohnhauser	Springer Publishers First Edition, 2015
8.	Analog Integrated Circuit Design	David Johns and Ken Martin	, John Wiley & Sons Inc., 2012.
9.	High Speed Data Converters IET Materials, Circuits & Devices,	Ahmed M.A.Ali	First Edition, 2016.
10.	Understanding Delta – Sigma Data Converters	S.Pavan,R. Schreier and Gabor.C.Temes	IEEE Press, First Edition, 2017
11.	Machine Learning Applications in Electronic Design Automation	Haoxing Ren, Jiang Hu	Springer International Publishing ISBN:9783031130762, 3031130766

S. No.	Titles	Author(s)	Publisher and Edition withISBN
12.	Deep Learning in Wireless Communications	Haijun Zhang and Ning Yang	Springer Nature; 2025th edition (20 October 2024),ISBN-10 : 9819763134,ISBN-13 : 978-9819763139

b) Online Educational Resources (OER):

1) https://www.allaboutcircuits.com/
2) https://nanohub.org/
3) https://ocw.mit.edu/
4) https://nptel.ac.in/
5) https://www.edx.org/
6) https://www.analog.com/en/design-center/design-tools-and-calculators/ltspice-simulator.html
7) https://kicad.org/
8) https://electronics.stackexchange.com/
9) https://www.eevblog.com/forum/
10) http://opencircuitdesign.com/
11) https://www.analog.com/

Q) Course Curriculum Developer

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A)	**Course Title:** Hybrid Circuit Packaging	Deemed to be University under Distinct Category
B)	**Course Code:** VMEL07	
C)	**Pre- requisite (s):** Semiconductor Packaging	

D) **Rationale:** The rationale for a course on hybrid circuit packaging lies in the critical need to bridge the gap between traditional and modern packaging technologies to meet evolving market demands and sustainability goals. This course aims to equip students with comprehensive knowledge and skills in combining materials, techniques, and technologies to create innovative, efficient, and eco-friendly packaging solutions. By understanding the integration of conventional materials with advanced technologies like smart packaging, bioplastics, and digital printing, students will be prepared to address contemporary challenges in packaging design, production, and distribution. This holistic approach not only enhances their technical expertise but also fosters creativity and strategic thinking necessary for the dynamic and competitive packaging industry. Hybrid circuit packaging integrated with AI enables precise monitoring and adaptive control of multi-technology assemblies, ensuring improved thermal management and signal integrity. AI algorithms enhance fault prediction and layout optimization, making hybrid systems more reliable and efficient for advanced applications.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following industry expected course outcomes by the learners.

Course Outcomes (COs)	Course Outcome Statements
VMEL07.CO1	Analyze electrical performance of Hybrid Packaging
VMEL07.CO2	Apply suitable interconnect technologies for specific applications
VMEL07.CO3	Implement reliability testing procedures to assess the long-term durability of hybrid packages
VMEL07.CO4	Evaluate vertical stacking and interconnect methods in 3D Packaging
VMEL07.CO5	Analyze the current industry trends, applications, benefits, and challenges of using nanomaterials in hybrid packaging.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)			
	PO-1 An ability to independently carry out research /investigation and development work to solve practical problems.	**PO-2** An ability to write and present a substantial technical report/document.	**PO-3** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program	**PO-4** Develop semiconductor package using design tools
VMEL07.CO1	3	3	3	3
VMEL07.CO2	2	2	2	3
VMEL07.CO3	2	2	2	3
VMEL07.CO4	3	3	2	2
VMEL07.CO5	2	2	3	3

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
VMEL07	PEC	Hybrid Circuit Packaging	45	15	-	30	90	03	30	70	20	-	-	-	120

H) Course Curriculum Detailing: For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP 2020, unique features like green skills, multidisciplinary aspects, societal connect, IKS, renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Describe concept and significance of hybrid packaging. *TSO 1b.* Analyze given substrate to be used in hybrid packaging, *TSO 1c.* Demonstrate knowledge of thick and thin film technologies. *TSO 1d.* Apply given heat dissipation technique *TSO 1e.* Analyze electrical performance by addressing signal integrity and power distribution.	**Unit-1.0 Fundamentals of Hybrid Packaging** 1.1 **Introduction to Hybrid Packaging:** Definition and importance, Historical development and trends, 1.2 **Materials and Components:** Substrates (ceramic, organic, metal), Active and passive components, Interconnect materials, 1.3 **Hybrid Packaging Technologies:** Thick and thin film technologies, Multichip modules (MCM), 1.4 **Thermal Management:** Heat dissipation techniques, Thermal interface materials, 1.5 **Electrical Performance Considerations:** Signal integrity, Power distribution	**CO1**
TSO 2a. Implement layout designs and floor plans for hybrid packages. *TSO 2b.* Describe various deposition techniques *TSO 2c.* Apply suitable interconnect technologies for specific applications, balancing performance, cost, and manufacturability. *TSO 2d.* Describe methods of encapsulation	**Unit-2.0 Design and Fabrication of Hybrid Packages** **2.1 Design Principles:** Layout design and floor planning, Thermal and electrical design considerations, 2.2 **Fabrication Processes:** Deposition techniques (screen printing, sputtering), Etching and patterning, Component placement and attachment, **2.3 Interconnect Technologies:** Wire bonding, Flip-chip bonding, Soldering and adhesives, 2.4 **Encapsulation and Protection:** Materials and methods for encapsulation, Hermetic vs. non-hermetic sealing, 2.5 **Design for Manufacturability (DFM):** Considerations for scalable and cost-effective production 2.6 **Process optimization in Hybrid Packaging using AI:** Use of different AI techniques for optimization of the process parameters	**CO2**
TSO 3a. Apply various inspection techniques to identify defects *TSO 3b.* Perform electrical testing methods to verify the functionality and performance of hybrid packages. *TSO 3c.* Implement reliability testing procedures to assess the long-term durability of hybrid packages.	**Unit-3.0 Testing and Quality Assurance** 3.1 Inspection Techniques: Optical and X-ray inspection, Electrical testing methods, 3.2 Reliability Testing: Thermal cycling, Mechanical stress testing, Environmental testing (humidity, corrosion), 3.3 Failure Analysis: Common failure modes, Techniques for root cause analysis, 3.4 Quality Control Standards: Industry standards	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 3d. Describe common failure modes in hybrid packages. *TSO 3e.* Apply industry standards and certifications to maintain high-quality production standards	and certifications (MIL-STD, IPC), 3.5 Statistical Process Control (SPC): Techniques for monitoring and controlling quality 3.6 Performance Prediction in Hybrid Packaging using AI: Use of AI in prediction of the performance characteristics of the Hybrid Packages 3.7 Reliability Prediction in Hybrid Packaging using AI: Use of AI in prediction of reliability in Hybrid Packages 3.8 Failure Analysis in Hybrid Packaging using AI: Use of AI in failure analysis of Hybrid Packages	
TSO4a. Describe integration of multiple functions into a single package. *TSO4b.* Evaluate vertical stacking and interconnect methods *TSO4c.* Describe Emerging Materials and Processes. *TSO4d.* Apply techniques for reducing package size *TSO4e.* Analyze the use of hybrid packaging in various applications.	**Unit-4.0 3D Packaging** **4.1 System-in-Package (SiP) Technologies:** Integration of multiple functions into a single package, Applications and benefits, **4.2 3D Packaging and Integration:** Vertical stacking and interconnect methods, Thermal and electrical challenges, **4.3 Emerging Materials and Processes,** Advanced substrates and interconnect materials, Innovations in fabrication techniques, **4.4 Miniaturization and High-Density Packaging:** Techniques for reducing package size, Challenges and solutions, 4.5 **Applications and Case Studies:** Case studies of hybrid packaging in consumer electronics, aerospace, and medical devices	**CO4**
TSO 5a. Evaluate current industry trends and market drivers that influence innovation in hybrid packaging. *TSO 5b.* Analyze the applications, benefits, and challenges of using nanomaterials in hybrid packaging. *TSO 5c.* Develop design strategies and packaging solutions for flexible and wearable electronics. *TSO 5d.* Apply principles of green materials and processes in hybrid packaging.	**Unit-5.0 Future Trends and Innovations in Hybrid Packaging** **5.1 Current Trends and Market Drivers:** Industry trends and market analysis, Drivers of innovation in hybrid packaging, **5.2 Nanotechnology in Hybrid Packaging:** Applications of nanomaterials, Benefits and challenges, 5.3 **Flexible and Wearable Electronics:** Design and packaging considerations, Materials and fabrication techniques, 5.4 **Environmental and Sustainability Issue:** Green materials and processes, Life cycle analysis and eco-friendly packaging, **5.5 Future Prospects:** Predictions for future developments, Research directions and emerging technologies	**CO5**

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

i. How can hybrid 2.5D and 3D IC packaging structures be optimized for minimal thermal resistance and mechanical stress while maintaining electrical performance?
ii. What are the long-term reliability concerns (e.g., electromigration, fatigue failure) in fan-out wafer-level packages integrating different chiplets or dies?
iii. What packaging-level design strategies can mitigate signal integrity degradation and crosstalk in high-speed interconnects in hybrid packages?
iv. How can PDNs in hybrid packages be optimized for low impedance, minimal noise, and IR drop across multi-die systems?
v. AI-Driven Fault Diagnosis and Thermal Optimization in Hybrid Circuit Packaging.

Note: Depending on the requirement of each laboratory experience, micro project and research-based problems, the performance may be conducted in online/offline mode and accordingly appropriate assessment tools may be used.

L) Suggested Term Work (TW):

a. Assignment(s):

- To prepare a specification sheet with design guidelines for a given circuit for hybrid circuit design
- To generate a process sheet with process parameters for fabrication of circuits on alumina substrates using thick-film microelectronics technology
- To provide process flow-chart with parameter values for assembly including die attachment, bonding and sealing for realisation of hybrid Multi chip module (MCM)
- AI-Driven Design and Analysis of Hybrid Circuit Packaging

b. Micro Projects: - (Sample Title/statements)

- Layout design of Application specific circuits as per hybrid circuit guidelines using CAD tools.
- Fabrication of circuits on alumina substrates using thick-film microelectronics technology
- Assembly including die attachment, bonding and sealing for realisation of Multi chip module (MCM)
- Data-Driven Optimization of Hybrid Package Layout for Thermal Efficiency
- Intelligent Fault Detection in Hybrid Circuit Packaging Using Machine Learning

M) Suggested Specification Table for End Semester Theory Assessment (ETA): Questions may be designed based on the higher taxonomy level of cognitive domain.

COs	Relevant Unit Number and Title	Marks
CO1	Unit-1.0 Fundamentals of Hybrid Packaging	12
CO2	Unit-2.0 Design and Fabrication of Hybrid Packages	12
CO3	Unit-3.0 Testing and Quality Assurance	16
CO4	Unit-4.0 3D Packaging	16
CO5	Unit-5.0 Future Trends and Innovations in Hybrid Packaging	14
Total		**70**

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. 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. To ensure learning, research-based problems may be designed and implemented.

O) Major Equipment, Tools and Software for Laboratory and Research Work: (Not Applicable)

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition withISBN
1.	Advanced Microsystems for Automotive Applications 2016	Jan Fischer-Wolfarth, Gereon Meyer	ISBN: 978-3319318916, Year: 2016
2.	Integrated Circuit Packaging, Assembly and Interconnections	William Greig	ISBN: 978-1461346281, Year: 2007
3.	Microelectronics Packaging Handbook: Subsystem Packaging	Rao Tummala, Eugene J. Rymaszewski, Alan G. Klopfenstein	ISBN: 978-0412084513, Year: 1997
4.	Fundamentals of Microsystems Packaging	Rao Tummala	ISBN: 978-0071458838, Year: 2001
5.	Handbook of 3D Integration, Volumes 1 and 2	Philip Garrou, Christopher Bower, Peter Ramm	ISBN: Volume 1: 978-3527409184, Volume 2: 978-3527409191, Year: 2008

S. No.	Titles	Author(s)	Publisher and Edition withISBN
6.	Advanced Packaging	Katsuaki Suganuma	ISBN: 978-3540447256, Year: 2004
7.	Electronic Packaging Science and Technology	King-Ning Tu, John W. Mayer, C. S. T. Chang	ISBN: 978-0471316290, Year: 2007

b) Online Educational Resources (OER):

1) Introduction to Semiconductor Packaging: https://www.coursera.org/learn/introduction-to-semiconductor-packaging
2) Advanced Semiconductor Packaging: [https://www.classcentral.com/course/advanced-packaging-200545]

Q) Course Curriculum Development Team

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****

A)	**Course Title:** Reliability and Yield Engineering	Deemed to be University under Distinct Category
B)	**Course Code:** VMEL08	
C)	**Pre- requisite (s):** Basic Semiconductor Packaging	

D) **Rationale:** Reliability and Yield Engineering in semiconductor packaging is crucial for ensuring that the final products meet stringent quality standards and perform consistently over their intended lifespan. Reliability engineering focuses on identifying and mitigating potential failure mechanisms through rigorous testing and design improvements, ensuring that devices operate under various environmental and operational conditions. Yield engineering, on the other hand, aims to maximize the number of functional units produced from each batch of semiconductor wafers by optimizing the manufacturing processes and minimizing defects. Together, these disciplines are essential for reducing costs, improving performance, and enhancing the overall competitiveness of semiconductor products in the market. By addressing both reliability and yield, manufacturers can ensure high-quality, dependable devices while maintaining efficient production processes. Artificial Intelligence (AI) is increasingly integrated into reliability engineering to predict failure modes and optimize test strategies using machine learning algorithms. AI-driven analytics enhance early fault detection, root cause analysis, and predictive maintenance in semiconductor packaging.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following industry expected course outcomes by the learners.

Course Outcomes (COs)	Course Outcome Statements
VMEL08.CO1	Apply given reliability analysis method on Semiconductor Package
VMEL08.CO2	Apply quality standards in Semiconductor Packaging
VMEL08.CO3	Implement given Reliability test on Semiconductor Package
VMEL08.CO4	Analyze failure mode in semiconductor packages
VMEL08.CO5	Implement given optimization technique for performance prediction of Package.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)			
	PO-1 An ability to independently carry out research /investigation and development work to solve practical problems.	**PO-2** An ability to write and present a substantial technical report/document.	**PO-3** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program	**PO-4** Develop semiconductor package using design tools
VMEL08.CO1	3	2	2	2
VMEL08.CO2	2	3	2	3
VMEL08.CO3	3	2	3	2
VMEL08.CO4	3	2	3	3
VMEL08.CO5	3	2	3	3

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		Total Marks (TA+TWA+LA)
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
VMEL08	SSC	Reliability & Yield Engineering	45	15	45	15	120	04	30	70	20	-	20	30	170

H) Course Curriculum Detailing: For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP 2020, unique features like green skills, multidisciplinary aspects, societal connect, IKS, renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Describe Quality & Reliability for Semiconductor Packaging *TSO 1b.* Implement screening procedures on Packages *TSO 1c.* Apply automated visual inspection tools to detect visible anomalies in semiconductor packages. *TSO 1d.* Apply given reliability analysis method on Package *TSO 1e.* Analyze the bath tub curve	**Unit-1.0 Quality and Reliability:** 1.1 Quality control. 1.2 Screening, visual inspection. 1.3 Reliability methods and analysis. 1.4 MTBF, MTTF, Bath tub curve etc. 1.5 Process optimization using AI	**CO1**
TSO 2a. Describe key industry standards in semiconductor packaging. *TSO 2b.* Apply quality standards in the production environment *TSO 2c.* Describe the usage of Quality Standards	**Unit-2.0 Quality Standards:** 2.1 Industry standards 2.2 MIL Standards, 2.3 Explanation and usage	**CO2**
TSO 3a. Analyze burn-in tests to identify early-life failures *TSO 3b.* Implement thermal cycling and thermal shock tests *TSO 3c.* Implement vibration and centrifuge tests *TSO 3d.* Implement radiation hardening tests, *TSO 3e.* Implement comprehensive reliability testing strategies	**Unit-3.0 Reliability tests:** 3.1 Burn-in Test. 3.2 Thermal cycling Test. 3.3 Thermal shock Test. 3.4 Vibration Test. 3.5 Centrifuge Test. 3.6 Radiation hardening & testing.	**CO3**
TSO 4a. Describe given failure mechanisms in semiconductor devices. *TSO 4b.* Apply systematic analytical approach to failure analysis *TSO 4c.* Implement key failure analysis tools *TSO 4d.* Analyze given failure modes and the importance of traceability in the failure analysis process. *TSO 4e.* Apply failure analysis concepts to real-world examples and case studies.	**Unit-4.0 Failure Analysis:** 4.1 Failure mechanisms, 4.2 Analytical approach, 4.3 failure analysis tools, 4.4 failure modes, 4.5 traceability, examples etc. 4.6 Failure Analysis using AI	**CO4**
TSO 5a. Implement given accelerated life test for reliability prediction of semiconductor device. *TSO 5b.* Apply principles of fault to analyze device failures. *TSO 5c.* Analyze yield data for identification of defects. *TSO 5d.* Implement given optimization technique for performance prediction of Package.	**Unit-5.0 Reliability Prediction:** 5.1 Accelerated life testing, 5 . 2 Failure mechanism, 5.3 Fault and failure physics. 5.4 Yield, 5.5 defect identification, process optimization and improvement. 5.6 Reliability prediction using AI 5.7 Performance prediction using AI	**CO5**

J) Suggested Laboratory Experience:

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
LSO 1.1. Thermal cycling test for component/ module	1.	Analyse the effect of temperature fluctuations on reliability and longevity of semiconductor components or modules	CO1
LSO 2.1 Thermal shock test for component/ module	2.	Analyse the device's response to rapid temperature changes, including potential failures such as cracking, delamination, or electrical degradation	CO2
LSO 3.1 Vibration test for component/ module	3.	Analyse the device's response to varying levels of mechanical stress	CO2
LSO 4.1. Centrifuge test for component/ module	4.	Evaluate the device's resistance to mechanical forces and design products capable of withstanding high levels of mechanical stress	C03
LSO 5.1. Accelerated life test for component/ module	5.	Ability to predict the long-term reliability and lifespan of semiconductor components or modules	CO5

K) Suggested Research Based Problems

i. What are the dominant failure mechanisms in TSV-based 3D IC packages under thermal cycling and how can they be mitigated through material and structural optimization?
ii. How do electromigration and TDDB affect interconnect reliability in fine-pitch packaging (e.g., flip-chip and fan-out)?
iii. What role does moisture ingress play in popcorn cracking and delamination in molded semiconductor packages, and how can packaging materials be improved for moisture resistance?
iv. How do temperature cycling and vibration conditions affect the long-term reliability of lead-free solder joints in BGA and CSP packages used in automotive and aerospace sectors?

Note: Depending on the requirement of each laboratory experience, micro project and research-based problems, the performance may be conducted in online/offline mode and accordingly appropriate assessment tools may be used.

L) Suggested Term Work (TW):

a. Assignment(s):

- To prepare screening procedure for semiconductor chip devices and thick-film patterned substrates as per MIL-STD
- To generate the process of performing thermal cycling and thermal shock tests for semiconductor chip devices and thick-film patterned substrates for reliability analysis
- To create accelerated life test for semiconductor chip devices and thick-film patterned substrates for ageing analysis
- To study AI-Driven Prediction of Failure Modes in Advanced Semiconductor Packaging and submit a report.

b. Micro Projects: - (Sample Title/statements)

- Visual inspection and Screening of the chip devices and thick-film patterned substrates as per MIL-STD
- Reliability analysis of chip devices and thick-film patterned substrates using thermal cycling and thermal shock tests
- Accelerated life testing and ageing analysis of chip devices and thick-film patterned substrates
- To develop a prototype AI-based model that predicts early signs of reliability degradation in semiconductor packages using test data.

M) Suggested Specification Table for End Semester Theory Assessment (ETA): Questions may be designed based on the higher taxonomy level of cognitive domain.

COs	Relevant Unit Number and Title	Marks
CO1	Unit-1.0 Quality and Reliability	14
CO2	Unit-2.0 Quality Standards	14
CO3	Unit-3.0 Reliability tests	14
CO4	Unit-4.0 Failure Analysis	14
CO5	Unit-5.0 Reliability prediction	14
Total		**70**

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. 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. To ensure learning, research-based problems may be designed and implemented.

O) Major Equipment, Tools and Software for Laboratory and Research Work:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience /Practical Number
1.	Computer system	Processor Intel Core i9, 12 GB RAM, 15 GB free disk space	All

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition withISBN
1.	Semiconductor Packaging: Materials Interaction and Reliability	Andrea Chen, Randy Hsiao-Yu Lo	2016, CRC Press, ISBN-10: 1439862052
2.	Reliability of Electronic Packages and Semiconductor Devices (Electronic Packaging and Interconnection Series)	Giulio Di Giacomo	ISBN: 978-0070170247, McGraw-Hill Education,1996
3.	Reliability of RoHS-Compliant 2D and 3D IC Interconnects	John H. Lau	ISBN: 978-0071753791, McGraw-Hill Professional, 2010

b) Online Educational Resources (OER):

Coursera:

1) Course: "Semiconductor Devices" by Dr. Ashish Goel (Stanford University)
2) Course: "Reliability of Electronic Components" by Prof. Gabriel A. Rincón-Mora (Georgia Institute of Technology)
3) Course: "Foundations of Manufacturing Processes and Systems" by Dr. Jack Zhou (Georgia Institute of Technology)

Udemy:

4) Course: "Semiconductor Packaging Technology" by Tech Tutorials.

Q) Course Curriculum Development Team

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A)	**Course Title:** CAD for VLSI	Deemed to be University under Distinct Category
B)	**Course Code:** VMEL09	
C)	**Pre- requisite (s):**	

D) **Rationale:** The design of all VLSI circuits is carried out by making extensive use Computer Aided Design (CAD)VLSI design tool. Due to continuous scaling of semiconductor technology, most of the VLSI designs employ millions of transistors and circuits of this size can only be carried out with the aid of CAD VLSI design tools. The VLSI design professional needs to have a good understanding of the operation of these CAD VLSI design tools as these are developed primarily for and by the VLSI design professionals. As part of the present introductory course the principles of operation of all the important modules that go into the construction of a complete VLSI CAD tool will be discussed. These include the design flow organization for VLSI, the standard cell-based synthesis methodologies for digital VLSI, floor planning and placement principles and related topics will all be covered. This course also introduces students to fundamental AI/ML techniques that are transforming modern EDA tools.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following industry expected course outcomes by the learners.

Course Outcomes (COs)	Course Outcome Statements
VMEL09.CO1	Identify tractable and intractable problems in VLSI CAD.
VMEL09.CO2	Use the suitable simulator to reduce the time and space complexities.
VMEL09.CO3	Construct high level synthesis problems in finding the solutions.
VMEL09.CO4	Analyze layout compaction algorithm.
VMEL09.CO5	Apply floor planning optimizing in VLSI CAD applications

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)			
	PO-1 An ability to independently carry out research /investigation and development work to solve practical problems.	**PO-2** An ability to write and present a substantial technical report/document.	**PO-3** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program	**PO-4** Develop semiconductor package using design tools
VMEL09.CO1	3	2	3	3
VMEL09.CO2	3	2	3	3
VMEL09.CO3	3	2	3	3
VMEL09.CO4	3	2	3	3
VMEL09.CO5	3	2	3	3

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
VMEL09	SSC	CAD for VLSI	45	15	45	15	120	04	30	70	20	-	20	30	170

H) Course Curriculum Detailing: For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP 2020, unique features like green skills, multidisciplinary aspects, societal connect, IKS, renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Explain the representation, terminology and complexity in computation of graphs. *TSO 1b.* Illustrate different graph algorithms. *TSO 1c.* Explain different search algorithms. *TSO 1d.* Evaluate differences between different search algorithms.	**Unit-1.0 Graph Theory and Computational Complexity** 1.1 Terminology, data structures for the representation of graphs, computational complexity 1.2 Examples of graph algorithms, depth-first search, breadth-first search 1.3 dijkstra's shortest-path algorithm, prim's algorithm for minimum spanning trees. 1.4 Geometric principles from Sulba Sutras and their relevance to computational geometry in VLSI design	**CO1**
TSO 2a. Illustrate the modelling and simulation procedures at gate and switch. *TSO 2b.* Write steps for applying delay modelling concept in gate level modeling. *TSO 2c.* Describe static and dynamic partition concepts.	**Unit-2.0 Simulation** 2.1 Gate-level modeling and simulation, signal modeling, gate modelling 2.2 delay modeling, connectivity modelling 2.3 compiler-driven simulation event-driven simulation 2.4 switch level modeling and simulation, connectivity and signal modelling. 2.5 Machine learning techniques for efficient simulation: surrogate models and fast simulation approaches.	**CO2**
TSO 3a. Explain concept and terminology of logic synthesis and verification. *TSO 3b.* Write process for applying ROBBD concept on logic expression implementation. *TSO 3c.* Elaborate hardware models for high level synthesis. *TSO 3d.* Explain scheduling and sequencing algorithms.	**Unit-3.0 Logic Synthesis and Verification** 3.1 Introduction to combinational logic synthesis, basic issues and terminology, 3.2 A practical example, binary decision diagrams, 3.3 ROBDD principles, ROBDD implementation and construction, ROBDD manipulation. 3.4 **High-level Synthesis:** Hardware models for high-level synthesis, hardware for computations, data storage, and interconnection, data, control, and clocks, internal representation of the input algorithm. 3.5 Vedic mathematics approaches for efficient computation in logic design.	**CO3**
TSO 4a. Illustrate the concepts of layout compaction, placement and partition.	**Unit-4.0 Layout Compaction:**	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 4b. Analyze Liao-Wang and Bellman-Ford layout compaction algorithm. *TSO 4c.* Elaborate constructive and iterative partitioning techniques. *TSO 4d.* Analyze KL partitioning algorithm.	4.1 Design rules, symbolic layout, problem formulation 4.2 Algorithms for constraint-graph compaction, a longest-path algorithm for dags, 4.3 The longest path in graphs with cycles, the liao- wong algorithm, the bellman-ford algorithm 4.4 Placement and Partitioning: Circuit representation, wire-length estimation, types of placement problem, placement algorithms, constructive placement, iterative improvement, partitioning, the Kernighan-Lin partitioning algorithm. 4.5 AI-driven approaches for layout compaction and advanced partitioning techniques	
TSO 5a. Illustrate the concepts of floor planning and routing. *TSO 5b.* Write process to apply floor planning optimizing techniques in shape function finding. *TSO 5c.* Explain Global routing and constraints. *TSO 5d.* Illustrate concepts of Left edge algorithm in VLSI CAD applications.	**Unit-5.0 Floor planning**: 5.1 Floor planning concepts, terminology and floorplan representation, 5.2 Optimization problems in floor planning, shape functions and floorplan sizing. 5.3 Routing: Types of local routing problems, area routing, channel routing, 5.4 Channel routing models, the vertical constraint graph, horizontal constraints and the left-edge algorithm channel routing algorithms. 5.5 Deep reinforcement learning for floor planning optimization 5.6 Ancient Indian architectural principles (Vastu Shastra) and their application to balanced spatial arrangements in VLSI layout	**CO5**

J) Suggested Laboratory Experiences:

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
LSO 1.1. Analyse the Breadth-First Search (BFS) algorithm on various types of graphs and understand its computational complexity.	1.	Implement the Breadth-First Search (BFS) algorithm	CO1
LSO 2.2 Analyse the Depth-First Search (DFS) algorithm on various types of graphs and	2.	Implement the Depth-First Search (DFS) algorithm	CO1

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
understand its computational complexity and applications.			
LSO 3.3 Analyse Dijkstra's algorithm for finding the shortest paths in weighted graphs and understand its computational complexity and applications.	3.	Implement Dijkstra's algorithm	CO1
LSO 4.2 Implement delay modelling concept in gate level modelling.	4.	Delay modelling concept in gate level modelling	CO2
LSO 5.2. Implement switch level modelling.	5.	Switch level modelling and simulation	CO2
LSO 6.2. Implement and construct ROBDD on logic expression to reduced graph	6.	ROBDD implementation and construction	CO3
LSO 7.1. Implement a high-level language (C/C++) and manually write equivalent HDL code (Verilog/VHDL) to Compare.	7.	High-level language (C/C++) and manually write equivalent HDL code (Verilog/VHDL)	CO3
LSO 8.1 Analyse Liao-Wang and Bellman-Ford layout compaction algorithm.	8.	Liao-Wang and Bellman-Ford layout compaction algorithm	CO4
LSO 9.1 Implement KL Partitioning algorithm	9.	KL partitioning algorithm.	CO4
*LSO 10.1*Implement Floor Planning Optimizing algorithm	10.	Floor planning optimizing techniques	CO5

K) Suggested Research Based Problems

i. As VLSI technology advances, designers face the challenge of optimizing floor plans to balance multiple objectives, such as area, power consumption, and timing performance. Traditional optimization techniques often address these objectives separately or assume trade-offs that may not hold in complex designs. Some challenges in complex designs are as following:

- To develop an efficient multi-objective optimization framework that simultaneously addresses area minimization, power reduction, and timing optimization while considering the practical constraints and variations in modern VLSI designs.
- Develop algorithms that can simultaneously optimize conflicting objectives, such as minimizing chip area while maximizing performance (speed) and minimizing power consumption.
- **Thermal and Power Constraints:** Integrate considerations for thermal management and power distribution within the floor planning optimization framework.

ii. AI/ML Research Problem: Explore how deep reinforcement learning can be applied to optimize placement and routing in VLSI design:

- Formulate the placement problem as a reinforcement learning environment
- Develop reward functions that effectively capture design objectives
- Compare performance with traditional algorithmic approaches
- Investigate transfer learning techniques to generalize across different design types

Note: Depending on the requirement of each laboratory experience, micro project and research-based problems, the performance may be conducted in online/offline mode and accordingly appropriate assessment tools may be used.

L) Suggested Term Work (TW):

a. Assignment(s):

- Design a combinational logic circuit (e.g., a 4-to-16 decoder or an ALU with basic operations) using a CAD tool. Simulate its functionality to verify correct operation.
- Compare the effectiveness of different placement algorithms for a given VLSI design problem.
- Apply machine learning techniques to predict timing characteristics of a circuit design.

b. Seminar Topics: -

- Energy-Efficient VLSI Design
- 3D IC Design and Optimization
- High-Level Synthesis (HLS) for VLSI Design
- Emerging Technologies in VLSI Design
- Machine Learning Applications in Electronic Design Automation

M) Suggested Specification Table for End Semester Theory Assessment (ETA): Questions may be designed based on the higher taxonomy level of cognitive domain.

COs	Relevant Unit Number and Title	Marks
CO1	Unit 1.0 Graph Theory and Computational Complexity	8
CO2	Unit 2.0 Simulation	8
CO3	Unit 3.0 Logic Synthesis and Verification	12
CO4	Unit 4.0 Layout Compaction	14
CO5	Unit 5.0 Floor planning	14
Total		**70**

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. 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. To ensure learning, research-based problems may be designed and implemented.

O) Major Equipment, Tools and Software for Laboratory and Research Work:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience /Practical Number
1.	Computer system	Processor Intel Core i9, 12 GB RAM, 15 GB free disk space	All
2.	Cadence full suit	Cadence academic bundles – Research, • Toolbox for Logic Synthesis • Toolbox for Physical Design • Toolbox for Physical Verification Toolbox for Custom Design and Simulation (Virtuoso)	All
3.	Synopsys	Synopsys toolbox for Floor Planning • IC Compiler II • Fusion Compiler • Custom Compiler	All
4.	Xilinx-VIVADO System	University VIVADO System • Logic Edition • EDK • System Generator	All

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition withISBN
1.	Algorithms for VLSI Design Automation,	S. H. Gerez	WILEY Student Edition, India, 2013. ISBN-9780471984894
2.	An Introduction to VLSI Physical Design	Majid Sarrafzadeh and C, K, Wong	McGraw Hill, 2011. ISBN-978-0070571945
3.	Algorithms for VLSI Physical Design Automation	Naveed Sherwani,	Kluwer Academic, 2012. ISBN-13 : 978-0792383932
4.	Practical Problems in VLSI Physical Design Automation	Sung Kyu Lim,	Springer Publications, 2011. ISBN-978-1402066269
5.	Machine Learning in VLSI Computer-Aided Design	Ibrahim (Abe) M. Elfadel, Duane S. Boning	Springer, 2019,ISBN-978-3030049713

b) Online Educational Resources (OER):

1) https://archive.nptel.ac.in/courses/106/106/106106088/
2) https://www.tessolve.com/blogs/decoding-vlsi-cad-exploring-design-flow-algorithms-and-tools/
3) https://dl.acm.org/doi/book/10.5555/19234

Q) Course Curriculum Developer

S. No.	Name	E-mail Address
1.	Prof. Sanjeet Kumar	skumar@nitttrbpl.ac.in

****

A)	**Course Title:** RF IC Design	 Deemed to be University under Distinct Category
B)	**Course Code:** VMEL10	
C)	**Pre- requisite (s):** RF engineering, IC fabrication technology, Basic Machine Learning/Data Science fundamentals, Digital Signal Processing	

D) **Rationale:** With the real-time implementation of Industry 4.0 and the advent of AI-driven wireless systems, the requirement for intelligent RF ICs has increased exponentially. Modern RF IC design now leverages AI/ML for optimization, automated design flows, and adaptive circuit behaviour. The speed of operation, power efficiency, and intelligent adaptation are prime concerns in contemporary RF IC design. This course provides comprehensive insight into fundamental Radio Frequency transceiver design integrated with cutting-edge AI/ML methodologies. Students will learn traditional RF circuit design alongside modern AI-assisted design optimization, machine learning-based parameter extraction, and intelligent circuit adaptation techniques. The curriculum includes hands-on experience with AI/ML tools for RF design automation and performance optimization.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following industry expected course outcomes by the learners.

Course Outcomes (COs)	Course Outcome Statements
VMEL10.CO1	Analyse wireless systems design using AI/ML optimisation techniques for trade-offs between noise, linearity, spectral cost, and computational complexity for GHz frequencies.
VMEL10.CO2	Design active and passive RF circuits using traditional methods enhanced with AI/ML optimisation algorithms and automated design flows.
VMEL10.CO3	Optimize RF Amplifier parameters using machine learning-based parameter extraction and performance prediction models.
VMEL10.CO4	Design and implement adaptive RF Oscillators with AI-driven frequency tuning and phase noise optimization.
VMEL10.CO5	Develop intelligent RF PLL circuits based on loop parameter optimisation and adaptive control.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)			
	PO-1 An ability to independently carry out research /investigation and development work to solve practical problems.	**PO-2** An ability to write and present a substantial technical report/document.	**PO-3** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program	**PO-4** Develop semiconductor package using design tools.
VMEL10.CO1	3	2	2	3
VMEL10.CO2	3	2	2	2
VMEL10.CO3	3	2	2	2
VMEL10.CO4	3	2	3	2
VMEL10.CO5	3	2	2	2

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		Total Marks (TA+TWA+LA)
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
VMEL10	SSC	RF IC Design	45	15	45	15	120	04	30	70	20	-	30	20	170

H) Course Curriculum Detailing: For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP 2020, unique features like green skills, multidisciplinary aspects, societal connect, IKS, renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Summarize the design paraments of RF IC system. *TSO 1b.* Describe the S-parameters method used for the modelling of RF components. *TSO 1c.* Discuss the design techniques used for RF components design and modelling. *TSO 1d.* Describe the low voltage and low power design requirements for the RF IC design. *TSO 1e.* Compare the RF Active and Passive components on the basis of design rules and characteristics. *TSO 1f.* Classify the types of components on the basis of RF design consideration.	**Unit 1.0 Overview of RF Systems and Active & Passive Components** 1.1 Overview of RF system: Introduction to RF Transceiver architectures, Multiple access techniques, Different wireless standards, Various modulation techniques used in RF system; Aspects and considerations of RF design: Low voltage and low power design, RF models of devices; Building blocks of RF, Noise and distortion measures Two port Noise theory, Noise Figure, Phase noise - Specification distribution over a communication link, and mitigation methods, Characteristics of passive components for RF circuits. Passive RLC networks. Transmission lines. Two-port network modelling. S-parameter model. The Smith Chart and its applications. 1.2 Active devices for RF circuits: SiGe MOSFET, GaAs pHEMT, HBT and MESFET. PIN diode. Device parameters and their impact on circuit performance. 1.3 Machine Learning in RF System Design: Introduction to ML applications in wireless communications. 1.4 AI-Driven RF Design Optimisation: particle swarm optimisation for RF circuits. 1.5 Automated S-Parameter Extraction: AI-based measurement and modelling techniques	**CO1**
TSO 2a. Analyze the general characteristics of RF amplifiers. *TSO 2b.* Classify the RF power amplifiers. *TSO 2c.* Describe the design procedure of a given type of RF amplifier. *TSO 2d.* Example the performance of Low noise and cascade amplifier design procedures with suitable examples.	**Unit-2.0 RF Amplifiers** 2.1 Linearity and large-signal performance. RF Power amplifiers: General properties, characteristics. Class A, AB and C Power amplifiers. Class D, E and F amplifiers. Modulation of power amplifiers. 2.2 RF Amplifier design: single and multi-stage amplifiers 2.3 RF power amplifiers: Design of class A, AB, B, C, D, E, F, G & H amplifiers - Low-noise amplifier (LNA), CS, CG & cascode amplifiers, Feedback amplifiers - Noise & linearity of amplifiers - Amplifiers using differential configurations - Low voltage topologies for LNA, DC bias networks for LNA, design of	**CO2**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
	broadband LNA, Case studies of RF power amplifiers and LNAs 2.4 Automated Design Space Exploration: ML algorithms for multi-objective amplifier optimization	
TSO 3a. Describe the principle of design of RF mixer IC *TSO 3b.* Critically analyze the working principle of various types of RF mixers. *TSO 3c.* Describe the step-by-step procedure of RF mixer IC design for the given specifications *TSO 3d.* Classify various types RF mixer noise and power matching.	**Unit-3.0 RF Mixers** 3.1 Mixers: Mixing operation, Mixing with nonlinearity, Quadratic mixers – Multiplier based mixers: 3.2 Single balanced and double balanced mixers – sub-sampling mixers 3.3 Mixer noise and linearity, Mixer with local oscillator switching, 3.4 popular mixer configurations like the Moore mixer, mixer with simultaneous noise and power match, mixer employing current reuse for low power applications 3.5 **AI-Enhanced Mixer Design**: Machine learning for mixer topology selection 3.6 **ML-Based Mixer Characterisation**: Automated parameter extraction	**CO3**
TSO 4a. Describe the working of the given type of RF Oscillators in detail. *TSO 4b.* Explain the working of the negative resistance oscillator with the help of a suitable sketch. *TSO 4c.* Designed a tuned oscillator for the given RF frequency band. *TSO 4d.* Differentiate between the performance of IC and component-based oscillators.	**Unit-4.0 RF Oscillators** 4.1 Negative resistance-based LC resonator, Colpitts oscillator, Differential topologies, Phase noise in oscillators - Tunable oscillators -Phase-locked loops (PLL), PLL components, in-band and out-of-band phase noise, Tuned Oscillators – Negative resistance oscillators 4.2 **AI-Driven Frequency Synthesis**: Machine learning for optimal VCO design 4.3 **Adaptive Phase** Noise **Optimisation**: Deep learning models for phase noise minimisation 4.4 **ML-Based** Oscillator **Stability Prediction**	**CO4**
TSO 5a. Explain the need for PLL and frequency synthesizer IC. *TSO 5b.* Describe the Charge pump. *TSO 5c.* Describe the working principle of the frequency synthesizer. *TSO 5d.* Describe the testing procedure of PLL ICs. *TSO 5e.* With a proper flow chart, describe the step-by-step PLL IC design.	**Unit 5.0 – PLL and Frequency Synthesizers** 5.1 PLL: Liberalized Model – Noise properties – Phase detectors – Loop filters and Charge pumps 5.2 Frequency Synthesizers: Integer-N frequency synthesizers – Direct Digital Frequency synthesizers 5.3 **AI-Optimized PLL Design**: Machine learning for loop parameter optimization 5.4 **Intelligent Jitter Reduction**: AI algorithms for jitter prediction and mitigation 5.5 **Design Automation Frameworks**: End-to-end	**CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
	AI design flows for RF circuits 5.6 **Performance Prediction Models**: Deep learning for circuit performance forecasting	

J) Suggested Laboratory Experiences:

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
LSO1.1. Test the performance of the given type of Passive RF component.	1.	Characterization of RF Passive Components.	CO-1
LSO 2.1. Test the performance of the given Active RF component.	2.	Characterisation of RF Active Components.	CO-1
LSO 3.1. Test the performance of the given type of Power amplifier.	3.	Design of Power Amplifiers.	CO-2
LSO 4.1. Test the performance of a Low Noise Amplifier (LNA)	4.	Design of Low Noise Amplifier.	CO-2
LSO 5.1. Test the performance of the given type of RF mixer.	5.	Design a Moore mixer for the given specification.	CO-3
LSO 6.1. Test the performance of the design RF	6.	Design and simulate the output of a RF oscillator IC using a CAD tool	CO -4
LSO 7.1. Test the performance of the RF-PLL	7.	Design and Implement- PLL And AI optimization	CO-5
LSO 8.1. Test the performance of the RF devices/circuits	8.	I-V Characterisation of RF device/circuit	CO-5
LSO 9.1. Test the performance of the Voltage Controlled Oscillator. *LSO 9.2.* ML model development	9.	Design of Voltage Controlled Oscillators. RF Performance Prediction using ML	CO-5,
LSO 10.1. Demonstrate Complete AI/ML workflow	10.	End-to-End AI RF Design Flow	CO-5

K) Suggested Research Based Problems

i. Suggest strategies to minimize the power dissipation in RF low-noise amplifiers (LNAs) without compromising sensitivity.

ii. Analysis of the trade-offs between wideband operation and noise figure in IoT RF front-end designs.

iii. Explore deep learning techniques for adaptive linearization, efficiency enhancement, and thermal management in mm-Wave systems.

iv. UWB RF ICs are critical for high-precision localization and sensing applications:- Develop reinforcement learning approaches for UWB circuit optimization to improve range, resolution, and energy efficiency.

v. Noise mitigation at RF frequency:-Create AI algorithms for real-time RF noise prediction and adaptive cancellation.

Note: Depending on the requirement of each laboratory experience, micro project and research-based problems, the performance may be conducted in online/offline mode and accordingly appropriate assessment tools may be used.

L) Suggested Term Work (TW):

a. Assignment(s):

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

- Calculate the bandwidth of an RF amplifier given its center frequency and quality factor (Q) and perform ML-based optimization, For a given RF circuit, design a matching network to match a 50 Ω source to a 75 Ω load.
- An RF filter has a centre frequency of 2 GHz and a bandwidth of 100 MHz. Design a basic LC resonant circuit for this filter.
- Propose a layout for a 2.4 GHz RF power amplifier and discuss the considerations for minimizing parasitics based on AI-driven layout optimization.

b. Micro Projects: - (Sample Title/statements)

- Prepare a report on the internet database available on RF components' technical specifications.
- Design a transceiver system for the given specifications**.**
- **AI-Enhanced RF Component Database**: Create ML-based component recommendation system.
- **Intelligent Transceiver Design**: Traditional design enhanced with AI optimization algorithms.
- **ML-Based RF Performance Predictor**: Develop neural networks for circuit performance prediction.
- **Adaptive RF System Prototype**: Build self-optimizing RF circuit demonstrator.

c. Visit:

- Visit locations where the RF components are used for various applications.

d. Seminar:

- Advanced AI/ML frameworks (TensorFlow, PyTorch) for RF applications
- Automated RF design tools with AI integration

- Edge AI hardware for RF processing
- Quantum machine learning fundamentals
- Federated learning protocols for RF systems

e. Self- Learning Topics:

- Use of various applications of RF design tools.
- Verification of RF IC design rules and limitations

M) Suggested Specification Table for End Semester Theory Assessment (ETA): Questions may be designed based on the higher taxonomy level of cognitive domain.

COs	Relevant Unit Number and Title	Marks
CO1	Unit-1.0 Overview of RF Systems and Active & Passive Components	13
CO2	Unit-2.0 RF Amplifiers	13
CO3	Unit-3.0 RF Mixers	16
CO4	Unit-4.0 RF Oscillators	14
CO5	Unit 5.0 – PLL and Frequency Synthesizers	14
Total		**70**

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. 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. To ensure learning, research-based problems may be designed and implemented.

O) Major Equipment, Tools and Software for Laboratory and Research Work:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience /Practical Number
1.	Computer system	Processor Intel Core i9, 32 GB RAM, 1TB SSD, Highend GPU, advanced graphic card	All
2.	Cadence full suit	Cadence academic bundles – Research, • Toolbox for Logic Synthesis, • Toolbox for Physical Design • Toolbox for Physical Verification	All

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience /Practical Number
		• Toolbox for Custom Design and Simulation (Virtuoso) • Cadence AMS designer • **AI-Enhanced EDA Tools**: Synopsys DSO.ai, Cadence Cerebrus Industry standard for designing and simulating mixed-signal circuits. Includes Spectre for analog simulation and AMS Designer for mixed-signal analysis.	
3.	Synopsys	Synopsys toolbox for Floor Planning • IC Compiler II • Fusion Compiler • Custom Compiler	All
4.	Keysight ADS (Advanced Design System)	• Full research version (RF and mixed-signal circuit design)	All
5.	Mentor Graphics Calibre	• ELDO RF simulator • Custom IC design suit • Used for layout versus schematic (LVS), design rule checks (DRC), and parasitic extraction. • Mentor Graphics Questa ADMS • Compatibility with other third party software like MATLAB, Cadence, ADS	All
6.	Magic VLSI (Open Source)	• Free tool for layout design with basic DRC and extraction.	All
7.	Other Advanced Software	• **Python/MATLAB with AI Libraries**: TensorFlow, PyTorch, Scikit-learn • **Cloud Computing Platforms**: AWS/Google Cloud for ML model training • **GPU Clusters**: For deep learning model development • **AutoML Platforms**: For automated machine learning workflows	ALL

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition withISBN
1.	Design of CMOS RF Integrated Circuits	Thomas H Lee,	Cambridge, 2004, ISBN-13 : 978-0521835398
2.	RF Circuit Design, Theory and Applications	Richard Chi-Hsi Li. Pavel B	John Wiley & Sons, 2011,978-8131762189
3.	Radio Frequency Integrated Circuits & Systems	Hooman Darabi	Cambridge University Press, 2015, ISBN-13 : 978-0521190794
4.	RF Microelectronics	Behzad Razavi	2nd Edition, Prentice Hall, 2011, ISBN-13 : 978-0137134731

S. No.	Titles	Author(s)	Publisher and Edition withISBN
5.	Analysis and Design of Integrated Circuits"	Paul R. Gray, Paul J. Hurst, Stephen H. Lewis, Robert G. Meyer	5th Ed., Wiley, 2009, ISBN-10 : 0470245999 ISBN-13 : 978-0470245996
6.	Neural Networks for RF and Microwave Design	K. C. Gupta, Q. J. Zhang	Artech House Book ISBN: 9781580531009
7.	Modeling and Optimization of Signals Using Machine Learning Techniques	Editor(s): Chandra Singh, Rathishchandra R. Gatti, K.V.S.S.S.S. Sairam, Manjunatha Badiger, Kumar S. Naveen, Varun Saxena	2024 Scrivener Publishing LLC, ISBN Print 9781119847687 |Online 9781119847717
8.	Deep Learning in Wireless Communications	Haijun Zhang and Ning Yang	Springer Nature; 2025th edition (20 October 2024), ISBN-10 : 9819763134,ISBN-13 : 978-9819763139

b) Online Educational Resources (OER):

1) https://ocw.mit.edu/(Analog and RF signal IC)
2) https://nptel.ac.in/(RF Integrated circuit design)
3) https://users.ece.gatech.edu/(Analig and RF IC design)
4) https://www.morganclaypool.com/
5) https://www.allaboutcircuits.com/
6) https://www.keysight.com/
7) https://www.analog.com/
8) https://www.edn.com/
9) https://www.rfcafe.com/
10) http://opencircuitdesign.com/magic/

Q) Course Curriculum Developer

S. No.	Name	E-mail Address
1.	Prof. Anjali Potnis	apotnis@nitttrbpl.ac.in

****

A)	**Course Title:** Project	Deemed to be University under Distinct Category
B)	**Course Code:** PD01	
C)	**Pre- requisite (s):**	

1. **Rationale:** The national policy on education has made provision for the implementation of outcome-based education, the design of imaginative curriculum, use of engaging pedagogy and formative assessment to assure the quality of education. The project-based instructional method is a learner-centric method that develops higher-order learning skills such as creative skills, critical thinking, investigative skills, analytical skills, entrepreneurship skills, incubation skills, communication skills and collaboration skills as mentioned in the NEP 2020. The project-based learning is systematically planned and implemented at the institute level across the programmes to exploit its full potential for learning. A guideline for managing and assessing the learners' project work is prepared to make all the stakeholders aware and educate them to assure quality learning through project work, make the process transparent and relevant.

2. Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
PD01	PD	Project	-	-	45	105	150	05	-	-	200	-	-	-	200

3. Broad guidelines for major project work

- The project's problems/themes/ should be relevant to current issues and practices of the industry/society.
- The project should address the majority of the outcomes at the programme level.
- Provision for self-assessment, assessment by teacher/expert should be incorporated to improve the quality of the project work and ensure a higher level of learning aligned to programme level outcomes.
- Provision to showcase a learning portfolio as a project output.
- The learners should be encouraged to publish the work (in the form of a paper, newspaper item, case study, report, etc.) after getting approval from the guide and the organization where the project is completed.

- The learners should submit the plagiarism check report during the final submission.
- Learners should record the output/ periodic achievements of significant interactions, feedback, discussions, and events at different milestones using a logbook.
- The schedule for project work is mentioned in table 1.
- The learners will be assessed during different stages of the project as per the rubrics mentioned in table 2.
- The project proposal and the report are to be prepared as per format 1 and format 2, respectively.

Table-1

4. Schedule of the Project work

S. No	Activities	Target Duration	Responsibility	Formative Assessment Marks Weightage	Output Expected
1.	**Conducting Orientation** • Rationale of the project • Credit of the project • Marks of the project • Expectations related to quality of project work • Road map of the project work	Week I	Dept. Team		
2.	**Stage 1: Project Planning**	Week II		20	
	• Preparation of synopsis/project proposal • Identification of project problem/theme • Interaction with the industry/organization resource person • Literature review • Tentative topic • Presentation and feedback (within department) • Finalization of topic • Preparation of project proposal/synopsis (as per format 1)				Draft Project Proposed
	• Presentation and assessment of project proposal • Approval of project proposal	Week IV	Dept. Team Using Rubric 1		Approved Project Proposal
3.	**Stage 2: Execution of Project Work as per the Project Proposal**	Week V		30	
	Execution of project work as per the action plan				
	Monitoring and assessment of progress and sharing of experience	Week VIII			
	Monitoring and assessment of progress and sharing of experience	Week XII			
4.	**Stage 3: Project Report Submission and Presentation**				
	Submission of draft report	Week XIV		20	Draft Report

S. No	Activities	Target Duration	Responsibility	Formative Assessment Marks Weightage	Output Expected
	• Presentation of draft project report • Internal assessment and review		Dept. Team		
	• Final submission • Presentation and assessment	Week XVI	Dept. Team and Expert		Final Project Report
	Submission of Report				

Format 1

Project Proposal

1. **Name of the Programme:**
2. **Broad Area/Theme of the Project:**
3. **Title of the Project:**
4. **Rationale:**
5. **Objectives:**
6. **Scope of the Project:**
7. **Project Outcomes:**

i. Carry out research /investigation independently
ii. Demonstrate a degree of mastery in areas of specialization and research
iii. Use alternative strategies/methods
iv. Demonstrate innovative abilities
v. Exhibit project management abilities
vi. Develop sustainable, environmentally and society-friendly output
vii. Demonstrate lifelong learning skills, learning-to-learn skills, and self-learning skills
viii. Adhere to professional ethics and values
ix. Write a technical project report
x. Defend project work

8. **Action Plan:**
9. **Literature Survey:**
10. **Proposed Methodology:**

i. Resources required
ii. Test
iii. Sampling
iv. Method
v. Model
vi. Any other (please specify)

11. **References:**
12. **Project Future Potential:**

Table 2

5. Assessment Rubrics for Project Work

S. No.	Criterion	Very Good (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
1.	**Project Planning** **Outcome:** Plan the Project Effectively				
1.1	**Rationale**	Clear and well-articulated. Strong justification based on real-world problems.	Depicts understanding of the background and purpose with some connection to practical or academic needs.	Rationale is stated but lacks depth or clarity. Justification is weak or only partially connected to real world problems.	Rationale is unclear. Fails to justify the need or relevance of the project.
1.2	**Literature Survey**	Comprehensive, well-structured review of relevant and up-to-date literature.	Adequate review covering relevant literature. Shows a good understanding of the topic.	Basic literature review with limited relevance or scope. Shows minimal understanding of the subject area.	Inadequate or poorly organized literature review. Sources are outdated, irrelevant, or insufficient.
1.3	**Outcome Proposed**	Proposed outcomes are well defined, realistic, and highly relevant to the problem statement.	Outcomes are adequately-stated and relevant to the problem statement.	Outcomes are defined but lack clarity. They are somewhat relevant but are vague.	Outcomes are poorly defined. They lack relevance to the problem statement.
2.	**Project Execution** **Outcome:** Execute the project as per the laid-down criteria				
2.1	**Appropriateness of the Methodology Adopted**	Methodology is highly appropriate and clearly aligned with project problem. Demonstrates deep understanding and use of tools/ techniques/ procedures.	Methodology is suitably aligned with the project problem. Shows good understanding and use of tools/ techniques/ procedures.	Methodology is somewhat appropriate but lack clarity or alignment with project problem. Shows basic understanding and use of tools/ techniques/ procedures.	Methodology is inappropriate, poorly explained. Shows little understanding and use of tools/ techniques/ procedures.
2.2	**Feasibility of Solution**	The proposed solution is highly feasible with clear consideration of time, resources, skills and constraints. Execution is practical.	The proposed solution is generally feasible with minor limitations. Resources and timelines are mostly considered. Some adjustments are needed for the project to be practical.	The proposed solution is partially feasible but shows gaps in planning or resource estimation. Face challenges in execution.	The proposed solution is not feasible due to unrealistic assumptions and poor planning. Execution appears impractical.
2.3	**Newness of the Project Work**	Project demonstrates high originality or innovation. Introduces a novel concept, approach, or solution that is significant different from existing work.	Project shows some originality. Modifies or improves existing ideas or solutions in a meaningful way. Offers partial innovation.	Project has limited newness. Mostly based on existing ideas with minor adjustments. Lacks significant innovation.	Project lacks originality. Direct replication of existing work with no new contribution.
2.4	**Resourcefulness**	Demonstrates exceptional initiativeness and creativity in	Shows good use of resources and tools. Demonstrate moderate	Makes basic use of resources with limited initiative.	Shows poor ability of utilizing/arranging resources.

S. No.	Criterion	Very Good (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
		utilizing/arranging resources effectively.	initiativeness and creativity in utilizing/ arranging resources.	Relies heavily on guidance.	
2.5	**Sustainability**	Project demonstrates strong sustainability considering all aspects like- environmental, economic, and social impacts.	Project demonstrates moderate sustainability practices considering some aspects like- environmental, economic, and social impacts.	Project demonstrates limited sustainability practices considering some aspects like- environmental, economic, and social impacts.	Project lacks sustainability considerations.
2.6	**Maintaining Daily Diary or Log Book**	Diary/log book is consistently and meticulously maintained. Entries are detailed, dated, and clearly reflect daily progress.	Diary/log book is periodically maintained with relevant entries. Most entries are dated and show a good record of activities and progress.	Diary/log book is maintained irregularly. Entries are brief or lack detail.	Diary/log book is poorly maintained or mostly incomplete. Important entries are missing or unclear.
3.	**Quality of Product/Process** **Outcome:** Ensure the Quality of Product/Process				
3.1	**Originality of Product**	The final product is original and creative. It presents unique features, functions, or designs not found in existing solutions.	The final product is somewhat original with some creative elements or improvements over existing ideas.	The product has limited originality. Mostly based on existing ideas or minor modifications.	The product lacks originality. It is a direct reproduction of existing work with no new features or creative input.
3.2	**Cost Effectiveness of Product/Process**	Process and/ product are highly cost-effective. Optimal use of resources. Demonstrates strong value-for-money.	Process and/ product are reasonably cost-effective. Resources are mostly used wisely, with acceptable cost.	Process and/ product show limited cost-effectiveness.	Process and/ product are not cost-effective. Inefficient use of resources.
3.3	**Proposed Outcomes Achieved**	All proposed outcomes are fully achieved.	Most of the proposed outcomes are achieved with satisfactory quality.	Some proposed outcomes are achieved with minor gaps.	A few or none of the proposed outcomes are achieved.
4.	**Project Report Writing** **Outcome:** Write Quality Project Report				
4.1	**Style and Language**	Language is clear, precise, and academically appropriate throughout. Style is formal, consistent, and well-suited, hence enhancing the overall quality of the report.	Language is generally clear and appropriate. Style is mostly formal and consistent. The quality of the report is acceptable.	Language is understandable, but is informal. Style occasionally deviates from the formal standards. The quality of the report is moderate	Language is unclear, informal, or inappropriate for a technical report. Style is inconsistent and affects the quality of the report.
4.2	**Quality of Related Diagrams/Drawings/Graphs in Project Report**	Diagrams/ drawings/ graphs are highly relevant, accurate, well-labelled and neatly presented.	Diagrams/ drawings/ graphs are mostly accurate, clear, and mostly relevant to the content. Properly labelled and adequately formatted.	Diagrams/ drawings/ graphs are present but lack clarity, proper labelling, or relevance.	Diagrams/ drawings/ graphs are missing/ incorrect, or poorly presented.

S. No.	Criterion	Very Good (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
4.3	**Future Scope of Project**	Demonstrates deep insight into how the project can be expanded/ improved/ applied in broader contexts.	Demonstrates awareness of how the project can be expanded/ improved/ applied in broader context, though some aspects may need more depth	Limited insight into how the project could be developed further.	No clear future scope identified or missing. Lacks understanding of how the project could be extended or applied further.
5.	**Quality of Presentation** **Outcome**: Demonstrate Good Presentation Skills				
5.1	**Comprehension of Concepts, Design and Methodology**	Demonstrates thorough understanding of underlying concepts, design and methodology.	Demonstrates good understanding of underlying concepts, design and methodology with minor gaps.	Demonstrates basic understanding of underlying concepts, design and methodology, but explanations are limited or partially correct with misconceptions developed.	Demonstrate poor or insufficient understanding of underlying concepts, design and methodology. Unable to explain or justify the approach clearly.
5.2	**Communication Skills**	Communicates ideas with exceptional clarity, fluency, and confidence. Language is precise and professional. Engages the audience effectively. Actively listens and responds thoughtfully.	Communicates clearly and confidently with minor lapses. Language is appropriate, and ideas are conveyed well. Demonstrate good listening skills.	Communicates basic ideas but with occasional lack of clarity or fluency. May struggle with appropriate vocabulary or organization of thoughts. Demonstrate fair listening skills.	Struggles to communicate ideas clearly. Lacks fluency, coherence, or appropriate vocabulary. Responses are unclear or incorrect. Poor listening and interaction with audience.
5.3	**Slide Organization**	Slides are visually appealing, well-organized, and professionally designed. Content is concise, relevant, and supports verbal presentation effectively. Excellent use of visuals (e.g., graphs, images, icons). Fonts, size, colours, and layout enhance readability.	Slides are well-structured. Content is mostly relevant and supports the spoken presentation. Visuals are used appropriately. Minor issues in font size, colour, and layout.	Slides have a basic structure but are cluttered. Lack proper visual support. Too much of text. Font size and colour is not appealing.	Slides are poorly designed or difficult to read. Content is disorganized, excessive, or irrelevant. Visuals are missing or irrelevant. Font size and colour are poor.
5.4	**Ability to Defend Questions**	Responds to all questions confidently, accurately and with deep understanding and proper justifications.	Responds to most questions correctly and confidently. Demonstrates good understanding with minor gaps in Justifications.	Responds to basic questions with partial accuracy. Shows limited understanding with weak justifications.	Unable to answer questions clearly or correctly. Responses reflect poor understanding.

Format 2

Project Report

1. **Name of the Programme:**
2. **Broad Area/Theme of the Project:**
3. **Title of the Project:**
4. **Rationale:**
5. **Objectives:**
6. **Scope of the Project:**
7. **Literature Survey:**
8. **Methodology used (as applicable):**

   i. Resources used
   ii. Test
   iii. Sampling
   iv. Method
   v. Model
   vi. Any other (please specify)

9. **Observation, Analysis, and Interpretation:**
10. **Reporting of Results and Conclusion:**
11. **Project Future Potential:**
12. **References:**
13. **Bibliography:**
14. **Annexure (as applicable):**

D) Course Curriculum Development Team

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Course Curriculum Detailing- Online Spell -1

A)	**Course Title:** Research Methodology	Deemed to be University under Distinct Category
B)	**Course Code:** PC01	
C)	**Pre- requisite (s):**	

D) **Rationale:** This course deals with the principles of research and significant phases of research using realistic plans to be followed. After completing the course, the researcher can choose the research field, research topic and formulate the research problem. The research methodology course provides an idea of literature review, critical thinking and logical reasoning, designing experiments, data analysis and interpretation, thesis writing, scientific writing, and presentation skills. The need, therefore, is for those concerned with research to pay due attention to designing and adhering to the appropriate methodology to improve the quality of research. The course emphasizes the principles of effective research and the need for a proactive approach in a successful research program. The researchers will get an insight into the privilege, honour, and associated research responsibilities.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following industry expected course outcomes by the learners.

Course Outcomes (COs)	Course Outcome Statements
PC01.CO1	Explain the basic concepts of research
PC01.CO2	Review the relevant literature effectively and efficiently
PC01.CO3	Make use of the guidelines to progress from the choice of the broad field of research to a specific topic of research
PC01.CO4	Apply critical thinking and analytical thinking in research methodology
PC01.CO5	Analyze well-structured research proposals and research papers invoking clearly outlined principles

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)		
	PO-1 An ability to independently carry out research /investigation and development work to solve practical problems.	**PO-2** An ability to write and present a substantial technical report/document.	**PO-3** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PC01.CO1	3	3	2
PC01.CO2	3	3	2
PC01.CO3	3	-	3
PC01.CO4	3	-	3
PC01.CO5	3	1	3

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
PC01	PC	Research Methodology	30	-	-	30	60	02	30	50	20	-	-	-	100

H) Course Curriculum Detailing: For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP 2020, unique features like green skills, multidisciplinary aspects, societal connect, IKS, renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Explain the History and Evolution of research and innovation *TSO 1b.* Classify the different types of research *TSO 1c.* Describe the step involved in the research *TSO 1d.* Explain the Relevance of Research for Innovation, Technology Development, and social relevance *TSO 1e.* State the importance of Hypotheses in Research	**Unit-1.0 Basic Concepts of Research** 1.1 History and Evolution of research and innovation 1.2 Types of Research 1.3 Research innovation and social relevance 1.4 Mandatory Steps in Research 1.5 Relevance of Research for Innovation and Technology Development 1.6 Importance of Hypotheses in Research	**CO1**
TSO 2a. Describe the Importance of Literature Review *TSO 2b.* Present a comprehensive overview of relevant research and theories on the topic *TSO 2c.* Apply strategies for good Literature Search *TSO 2d.* Organize Referencing Ethics, Paraphrasing, and Summarizing *TSO 2e.* Make use of literature review tools	**Unit-2.0 Literature Review** 2.1 Importance of Literature Review 2.2 Characteristics of Good Literature Review 2.3 Review and Strategies for Good Literature Search 2.4 Referencing Ethics, Paraphrasing and Summarizing 2.5 Tools for literature review	**CO2**
TSO 3a. Classify the data types for analysis *TSO 3b.* Design experiments *TSO 3c.* Describe the methods of data collection *TSO 3d.* Draw valid conclusions from sampling methods, statistical analysis *TSO 3e.* Identify the Research problem *TSO 3f.* Demonstrate narrowing down the problem *TSO 3g.* List the Factors to be considered for the selection of the problem	**Unit-3.0 Research Problem Formulation** 3.1 Data collection, data analysis, data types, and interpretation 3.2 Designing of Experiments 3.3 Methods of data collection 3.4 Sampling methods, statistical analysis, and displaying of data 3.5 Research problem identification 3.6 Narrowing down the problem 3.7 Factors to be considered for the selection of the problem	**CO3**
TSO 4a. Construct Out of the Box Thinking problem *TSO 4b.* Interpret Transformation to Impossible Thinking *TSO 4c.* Distinguish Convergent and Divergent Thinking *TSO 4d.* Evaluate the selection of idea *TSO 4e.* Evaluate the line of reason for thinking critically *TSO 4f.* Compare Critical and Analytical Thinking in Research Methodology	**Unit-4.0 Critical and Analytical Thinking** 4.1 Out-of-Box Thinking 4.2 Transformation to Impossible Thinking 4.3 Convergent and Divergent Thinking 4.4 Generation, Evaluation, and Selection of Ideas 4.5 Critical thinking 4.6 Comparison of Critical and Analytical Thinking	**CO4**
TSO 5a. Illustrate the Structure of a Good Research Proposal *TSO 5b.* Write good research proposal	**Unit -5.0 Research Proposal**	**CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 5c. List the tips for compilation *TSO 5d.* Classify the types of scientific report *TSO 5e.* Develop structure and components of the conference *TSO 5f.* Write the report with ethics and scientific conduct *TSO 5g.* Analyze the presenting work is from another source with or without consent of the original author	5.1 Getting Started to Write a Research Proposal 5.2 Tips for Compilation 5.3 Scientific writing: types of scientific report 5.4 Structure and components of a conference 5.5 Arts of writing, ethics, and scientific conduct 5.6 Journal articles and thesis writing 5.7 Plagiarism	

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

Research is a unique combination of art and science. Research is presumed to be associated with unpredictable uncertainties and variable degrees of technological endeavour. Research methodology is a systematic approach to reducing the degree of uncertainties. It helps in shaping the research orientation of a researcher. In this module, students were introduced to various aspects of research methodology. The students have been exposed to effective methods of problem definition, literature survey, reading and analysing research papers, design of experiments, ethical issues, and academic standard issues.

i. This part of the task is structured to test the researcher's comprehension skills and ability to adapt quickly to the rudimentary phase of the research cycle. The list of tasks to be performed is as follows.

- Identification of "Specific Field of Research" of the researcher's interest.
- Through a literature search, two doctoral theses have to be chosen that are closely related to an identified specific field of research
- The Abstract and Chapters on the Introduction, Conclusions, and Future recommendations of the two theses have to be reviewed

ii. Based upon the above-referred review, a technical note should be developed highlighting the:

- Introduction to the Identified "Specific Field of Research"
- Assumptions of the individual thesis
- Techniques invoked along with its merits and constraints of the individual thesis
- Relative differences in the approaches and scope of the two theses
- Views on the feasibility of incorporating the recommended suggestions of individual thesis
- Appreciation of the individual thesis reviewed with emphasis on introduction, problem definition and suggested future work

Note: Depending on the requirement of each laboratory experience, micro project and research-based problems, the performance may be conducted in online/offline mode and accordingly appropriate assessment tools may be used.

L) Suggested Term Work (TW):

a. Assignment(s):

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

b. Seminar Topics:

- The Role of Literature Review in Building Research Frameworks
- Digital Tools for Research Data Collection and Management
- AI and Machine Learning in Research Methodology

M) Suggested Specification Table for End Semester Theory Assessment (ETA): Questions may be designed based on the higher taxonomy level of cognitive domain.

COs	Relevant Unit Number and Title	Marks
CO1	Unit-1.0 Basic Concepts of Research	08
CO2	Unit-2.0 Literature Review	08
CO3	Unit-3.0 Research Problem Formulation	12
CO4	Unit-4.0 Critical and Analytical Thinking	12
CO5	Unit -5.0 Research Proposal	10
Total		**50**

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. 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. To ensure learning, research-based problems may be designed and implemented.

O) Major Equipment, Tools and Software for Laboratory and Research Work: (Not Applicable)

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	The Craft of Research	Booth W. C, Colomb and G.G Williams	Chicago University Press
2.	Research Methods	Willium M.K and Trochim. (2003)	2nd Edition, Biztantra Publications
3.	The Foundation of Research	Jonathan Grix. (2004)	Palgrave Study Guides
4.	The Post Graduate Research	Wisker Gina. (2001)	Palgrave
5.	The Unwritten Rules of Ph.D research	Rugg G. and Petre M. (2004)	Open University Press

b) Online Educational Resources (OER):

1) https://www.youtube.com/watch?v=TEqYnV6KWfY
2) https://www.youtube.com/watch?v=hECPeKv5tPM
3) https://www.youtube.com/watch?v=G3DUaQokOK8
4) https://onlinecourses.nptel.ac.in/noc23_ge36/preview
5) https://nptel.ac.in/courses/121106007
6) https://www.youtube.com/watch?v=E2gGF1rburw
7) https://www.youtube.com/watch?v=E2gGF1rburw&list=PLyqSpQzTE6M8F_P8lgjvmqiDEoFGLzG4h
8) https://www.youtube.com/watch?v=NNPiJ20JcFI&list=PLyqSpQzTE6M8F_P8lgjvmqiDEoFGLzG4h&index=8

Q) Course Curriculum Development Team

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A)	**Course Title:** Curriculum & Assessment	Deemed to be University under Distinct Category
B)	**Course Code:** PC02	
C)	**Pre- requisite (s):**	

D) **Rationale:** National Education Policy (NEP) 2020 envisions many innovations and reforms in the higher education. Major reforms mentioned are overhauling of curriculum, assessment and pedagogy. One of the major reforms is outcome-based curriculum design and development in the context of NEP:2020. Accordingly, all universities and institutions have started transforming the curriculum of higher education programmes to align with national policy directives and stakeholder's need in the changed context and era of industry 4.0 and skills demands. Many challenges and issues are envisaged in curriculum design & development, implementation, pedagogy and assessment in the context of NEP 2020.

The course curriculum on curriculum and assessment aims to deliberate on capability and capacity building of learners, policy makers, teachers etc. trainers on different reforms in curriculum design & development, pedagogy and assessment.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following industry expected course outcomes by the learners.

Course Outcomes (COs)	Course Outcome Statements
PC02.CO1	Develop awareness about the key concepts of outcome-based education and curriculum in the context of higher education.
PC02.CO2	Design innovative programme structure with scheme of studies and assessment as per the curriculum and assessment reforms envisaged in NEP 2020.
PC02.CO3	Implement the curriculum effectively to ensure the achievement of stated learning outcomes.
PC02.CO4	Revise the existing programme curriculum based on curriculum evaluation.
PC02.CO5	Assess the learners' performance by using the appropriate tools of assessment, as per need.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)		
	PO-1 An ability to independently carry out research /investigation and development work to solve practical problems.	**PO-2** An ability to write and present a substantial technical report/document.	**PO-3** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PC02.CO1	1	1	3
PC02.CO2	3	3	3
PC02.CO3	2	1	3
PC02.CO4	3	3	3
PC02.CO5	1	1	3

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
PC02	PC	Curriculum and Assessment	30	-	-	30	60	02	20	30	50	-	-	-	100

H) Course Curriculum Detailing: For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP 2020, unique features like green skills, multidisciplinary aspects, societal connect, IKS, renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Explain the concept of outcome-based education *TSO 1b.* Differentiate between outcome-based curriculum and conventional curriculum. *TSO 1c.* Identify the curriculum reforms envisaged in NEP 2020 *TSO 1d.* Distinguish between curriculum and syllabus *TSO 1e.* Identify the key stakeholders of curriculum document	**Unit-1.0 Outcome Based Education and Curriculum** 1.1 Outcome Based Education (OBE) and curriculum. 1.2 Curriculum reforms in the context of NEP 2020- multidisciplinary and holistic curriculum. 1.3 Curriculum &syllabus- purposes and scope 1.4 Stakeholders of curriculum document, 1.5 Characteristics of good Curriculum document. 1.6 Policy directives for outcome-based curriculum development-NBA, AICTE and UGC	**CO1**
TSO 2a. Use contemporary approaches for design and development of curriculum. *TSO 2b.* Identify the key stages in curriculum planning, design and development. *TSO 2c.* Conduct need assessment from stakeholders (students, teachers, industry and alumni). *TSO 2d.* Use the need assessment results to arrive at curriculum design decisions. *TSO 2e.* Develop programme structure with scheme of studies and assessment for multidisciplinary programme. *TSO 2f.* Integrate the key curriculum and assessment reforms outlined in NEP 2020. *TSO 2g.* Describe the key components of outcome-based curriculum document. *TSO 2h.* Identify the unique features of multidisciplinary outcome-based curriculum	**Unit-2.0 Outcome Based Curriculum Design & Development** 2.1 Approaches of Curriculum Development: Tyler and Taba Model. 2.2 Stages of curriculum development-: Curriculum planning & design 2.3 Need assessment for curriculum design and development from different stakeholders. Design of tools for need assessment. 2.4 NEP 2020 curriculum and assessment reforms. 2.5 Innovative and flexible Programme Structure Development– Scheme of studies and scheme of assessment. 2.6 Flexible curriculum – Integration of emerging areas/technology in programme structure development. 2.7 Unique features of multidisciplinary outcome-based curriculum. 2.8 Elements/ Components of whole programme curriculum document. 2.9 Elements/Components of course curriculum document. 2.10 Domains of learning and course outcomes. Formulating course outcomes.	**CO2**
TSO 3a. Identify the roles of different stakeholders in effective curriculum implementation.	**Unit-3.0 Curriculum Implementations & Evaluation**	**CO3, CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 3b. Evolve strategies for effective curriculum implementation. *TSO 3c.* Solve issues and challenges faced during effective implementation of curriculum. *TSO 3d.* Analyze critical factors that influence the success or failure of curriculum implementation. *TSO 3e.* Apply the CIPP model to review and evaluate curriculum. *TSO 3f.* Revise the curriculum of programme and courses. *TSO 3g.* Develop e-contents for specific topic/sub topic as per outcomes stated.	3.1 Effective Curriculum Implementation: Issues and Challenges. 3.2 Innovative pedagogical methods /strategies for effective curriculum implementation, use of ICT for teaching learning. 3.3 Role of different stakeholders in effective curriculum implementation. 3.4 Factors influencing curriculum implementations, institutional support, teacher's competence, and student's engagement, entry level knowledge, skills and attitude etc. 3.5 CIPP model of curriculum evaluation. 3.6 Curriculum evaluation –strategies for effective implementation of curriculum. 3.7 Develop action plan for review and revision of existing programme and courses curriculum, based on evaluation results and emerging trends in education world of work 3.8 Role of teachers in effective curriculum implementation & evaluation considering the four pillars of NEP 2020- Access, Equity, Quality and Accountability. 3.9 Frameworks for Learning/Instructional material development: ADDIE and ASSURE 3.10 Leaning /Instructional materials development (e-contents).	
TSO 4a. Identify the purposes of outcome-based assessment *TSO 4b.* Differentiate between assessment, measurement and evaluation. *TSO 4c.* Apply appropriate assessment tools to assess the course outcomes across different learning domains. *TSO 4d.* Design rubrics for assessing student's performance during multiple tasks. *TSO 4e.* Design specification table *TSO 4f.* Design different types of questions	**Unit-4.0 Learners' Assessment** 4.1 Assessment, Measurement and Evaluation. 4.2 Characteristics of assessment – Validity, Reliability, Objectivity and Practicability. 4.3 Basic concepts of outcome-based assessment: Assessment for learning, Assessment of learning, Assessment as learning, Assessment before learning, process and product assessment. Issues and challenges in assessment. 4.4 Criterion Reference Testing (CRT) and Norms Reference Testing (NRT). 4.5 Direct and indirect tools of assessment 4.6 Assessment of outcomes in Cognitive, Affective, and Psychomotor domain.	**CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
	4.7 Rubrics based assessment: Design of Rubric for assessing Project work, Industrial Training, Seminar, Laboratory experiences, workshop experiences, etc. 4.8 Design of Specification table for assessment in cognitive and psychomotor domain. 4.9 Different types of questions-Multiple choice questions, short answer question, structured essay questions, etc. 4.10 Bloom's taxonomy and design of question paper.	

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

i. Carry out the need assessment from different stakeholders and analyze the same to draw the curricular decisions for development of multidisciplinary flexible programme structure of Diploma/Degree programmes.

ii. Identify the norms of project, internship and industrial training in AICTE and UGC guidelines for integration in curriculum design and development.

Note: Depending on the requirement of each laboratory experience, micro project and research-based problems, the performance may be conducted in online/offline mode and accordingly appropriate assessment tools may be used.

L) Suggested Term Work (TW):

a. Assignment(s):

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

- Prepare a basket of emerging technology courses, open elective courses, emerging stream specific courses, NEP courses, NEP courses as per need of specific programme for integration in programme structure across the programme.
- Develop most valid and reliable T-L and assessment tool for effective implementation and assessment of capstone/major project work.
- Features of NCrF for Curriculum Design and Development
- Unique features of NHEQF
- Innovative programme structure development by integration of academic, experiential learning and vocational component.

b. Seminar Topics:

- Emerging and futuristic models and approaches of curriculum design and development
- NEP envisions and curriculum ad Assessment Reforms.
- Categorize the cluster of programme courses, as pre the different category of courses.
- Map the appropriate courses as per the different category of courses.

M) Suggested Specification Table for End Semester Theory Assessment (ETA): Questions may be designed based on the higher taxonomy level of cognitive domain.

COs	Relevant Unit Number and Title	Marks
CO1	Unit 1.0 Outcome Based Education and Curriculum	04
CO2	Unit 2.0 Outcome Based Curriculum Design & Development	10
CO3, CO4	Unit 3.0 Curriculum Implementations & Evaluation	08
CO5	Unit 4.0 Learners' Assessment	08
Total		**30**

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. 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. To ensure learning, research-based problems may be designed and implemented.

O) Major Equipment, Tools and Software for Laboratory and Research Work: (Not Applicable)

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Curriculum: Foundations, Principles & Theories	Ornstein, A.C	Pearson; 7th edition (6 January 2016), ISBN-10: 0134060350, ISBN-13: 978-0134060354
2.	Concept-based Curriculum and Instruction	Erickson, H.L.	Publisher: Corwin; 1st edition (1 August 2006), ISBN-10: 141291700X, ISBN-13: 978-1412917001

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
3.	Principles of Curriculum Construction	Balasara, M	Kanishka; First Edition (1 January 2017), ISBN-10: 8173916217 ISBN-13: 978-8173916212
4.	Advanced Curriculum Construction	Prasad, J. &Kaushik, V. K	Publisher: Kanishka Prakshan; First Edition (1 January 2009), ISBN-10: 8173916772, ISBN-13: 978-8173916779
5.	'Curriculum theory and practice'	Smith, M. K. (1996, 2000)	www.infed.org/biblio/b-curric.htm.
6.	Outcome-Based Curriculum in Engineering Education	Shashi Kant Gupta, Joshua Earnest	PHI Learning; 1st edition (1 November 2021)
7.	Outcome Based Education: A Practical Guide for Higher Education Teachers	Deepesh Divaakaran	Notion Press (30 June 2023); Notion Press Media Pvt Ltd, ISBN-13: 979-8890268945
8.	Designing and Implementing the Outcome-Based Education Framework: Theory and Practice	P P Noushad	Springer (14 December 2024), ISBN-10: 9819604397, ISBN-13: 978-9819604395
9.	Assessment for Learning	Paul Black, Chris Harrison, Clara Lee, Bethan Marshall, Dylan Wiliam	Open University Press (16 September 2003), ISBN-10: 0335212972 ISBN-13: 978-0335212972
10.	ASSESSMENT FOR LEARNING [Paperback]	DR.A.JAHITHA BEGUM, DR.G.LOKANADHA REDDY	RAKHI PRAKASHAN; First Edition (1 January 2015), ISBN-10: 9385195247 ISBN-13: 978-9385195242
11.	Curriculum Implementation and Instruction	Abayomi Oluwatelure Temitayo	LAP Lambert Academic Publishing (2 March 2011), ISBN-10: 9783843362740, ISBN-13: 978-3843362740

b) Online Educational Resources (OER):

1) https://onlinecourses.swayam2.ac.in/ntr24_ed10/preview
2) https://nptel.ac.in/courses/127105017
3) https://onlinecourses.swayam2.ac.in/ntr20_ed03/preview
4) https://onlinecourses.swayam2.ac.in/ntr22_ed16/preview
5) https://onlinecourses.swayam2.ac.in/ntr19_ed16/preview
6) https://www.youtube.com/watch?v=zhvzu8WkQs4
7) http://youtube.com/watch?v=vRKRQi2QnAQ&t=5s

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A)	**Course Title:** Indian Knowledge System (IKS)	Deemed to be University under Distinct Category
B)	**Course Code:** NEP06	
C)	**Pre- requisite (s):**	

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

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following industry expected course outcomes by the learners.

Course Outcomes (COs)	Course Outcome Statements
NEP06.CO1	Identify the rich heritage and legacy residing in our Indian Knowledge systems.
NEP06.CO2	Correlate the technological & philosophical concepts of IKS with engineering domain specific problems and local problems for finding out possible solutions

F) **Suggested Course Articulation Matrix (CAM):**

Course Outcomes (COs)	Programme Outcomes (POs)				
	PO-1 Apply knowledge of management theories and practices to solve business problems.	**PO-2** Foster Analytical and critical thinking abilities for data-based decision-making.	**PO-3** Ability to develop Value based Leadership ability.	**PO-4** Ability to understand, analyze and communicate global, economic, legal, and ethical aspects of business.	**PO-5** Ability to lead themselves and others in the achievement of organizational goals, contributing effectively to a team environment.
NEP06.CO1	1	-	1	-	-
NEP06.CO2	1	1	1	-	-

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
NEP06	NEP	Indian Knowledge System (IKS)	15	-	-	15	30	01	25	-	25	-	-	-	50

H) Course Curriculum Detailing: For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP 2020, unique features like green skills, multidisciplinary aspects, societal connect, IKS, renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Explain the architecture of the Ancient Indian Knowledge Systems. *TSO 1b.* List the salient features of IKS. *TSO 1c.* Comprehend the given IKS model. *TSO 1d.* Identify the role and relevance of the given IKS model in contemporary society.	**Unit-1.0 Introduction to Indian Knowledge Systems** 1.1 Overview of IKS 1.2 Organization of IKS – चतुर्दश-विद्यास्थानं 1.3 Conception and Constitution of Knowledge in Indian Tradition 1.4 The Oral Tradition 1.5 Models and Strategies of IKS	**CO1**
TSO 2a. Enlist the importance of Veda, Vedanga, Visaya, Siksaka. *TSO 2b.* Describe the given IKS domain. *TSO 2c.* Identify elements of mentioned IKS domains that are relevant to Technical Education System. *TSO 2d.* Correlate the elements of mentioned IKS domains with given engineering domain.	**Unit-2.0 Overview of IKS domains and relevance in current Technical Education System.** 2.1 The Vedas as the basis of IKS 2.2 Overview of all the six Vedāṅgas 2.3 Relevance of following IKS domains in present Technical Education System: • Arthashastra (Indian economics and political systems) • Ganita and Jyamiti (Indian Mathematics, Astronomy and Geometry • Rasayana (Indian Chemical Sciences)	**CO1, CO2**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
	• Ayurveda (Indian Biological Sciences / Diet & Nutrition) • Jyotish Vidya (Observational astronomy and calendar systems) • Prakriti Vidya (Indian system of Terrestrial/ Material Sciences/ Ecology and Atmospheric Sciences) • Vastu Vidya (Indian system of Aesthetics-Iconography and built-environment /Architecture) • Nyaya Shastra (Indian systems of Social Ethics, Logic and Law) • Shilpa and Natya Shastra (Indian Classical Arts: Performing and Fine Arts) • Sankhya and Yoga Darshna (Indian psychology, Yoga and consciousness studies) • Vrikshayurveda (Plant Science / Sustainable agriculture/food preservation methods)	

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems:

a. Relevance of Ayurveda in Modern Healthcare

- Problem: How can Ayurvedic principles be integrated into modern medical practices to provide holistic healthcare solutions?
- Focus: Researching the efficacy of Ayurvedic treatments in chronic diseases, lifestyle disorders, and preventive healthcare, and exploring ways to bridge Ayurveda with modern healthcare systems.

b. Vedic Astronomy and Modern Astrophysics: A Comparative Study

- Problem: What are the similarities and differences between ancient Vedic astronomy and modern astrophysical theories?
- Focus: Exploring ancient Indian astronomical texts like the *Surya Siddhanta* and their insights into planetary motions, eclipses, and cosmology, and comparing these with contemporary astronomical models.

c. Yoga and Mental Health: A Scientific Perspective

- Problem: How can the practice of Yoga and its underlying philosophical principles contribute to mental health therapies in modern psychology?
- Focus: Exploring the psychological benefits of yogic practices like meditation, pranayama, and asanas, and scientifically evaluating their impact on anxiety, depression, and stress management.

d. The Role of Ancient Indian Agriculture in Sustainable Farming Practices

- Problem: How can ancient Indian agricultural practices, such as organic farming and crop rotation, be applied to address contemporary challenges in sustainable agriculture?
- Focus: Investigating ancient texts like the *Krishi-Parashara* and traditional knowledge in water management, soil conservation, and sustainable farming, and adapting these to modern agricultural practices.

e. Vedic Mathematics and Its Role in Contemporary Education

- Problem: How can Vedic Mathematics techniques be integrated into modern education systems to enhance students' computational skills and logical reasoning?
- Focus: Researching the techniques of Vedic Mathematics and exploring their effectiveness in improving mathematical literacy and problem-solving abilities among students.

f. Natyashastra and Its Influence on Modern Theatre and Performing Arts

- Problem: What are the enduring influences of *Natyashastra*, the ancient Indian treatise on performing arts, on modern theatre, dance, and cinema?
- Focus: Analyzing the principles of *Natyashastra* in terms of aesthetics, drama, and performance, and exploring its relevance and application in contemporary performing arts.

g. Traditional Indian Water Management Systems: Lessons for the Future

- Problem: How can traditional water management systems, like step wells and rainwater harvesting structures from ancient India, be revived to solve modern water scarcity issues?
- Focus: Investigating ancient Indian water management practices and their sustainability, and exploring their application in current water conservation efforts and urban planning.

h. Ancient Indian Contributions to Astronomy and Navigation

- Problem: What were the contributions of ancient Indian scholars to the field of navigation and astronomy, and how can this knowledge be applied in modern scientific advancements?
- Focus: Exploring the contributions of ancient Indian navigators and astronomers in calculating planetary positions, timekeeping, and navigation, and their influence on global knowledge systems.

i. Military Science in Ancient India and Its Lessons for Modern Defense Strategies

- Problem: What can modern military strategists learn from ancient Indian military texts like *Niyuddha Kala* and *Arthashastra*?
- Focus: Studying ancient Indian warfare techniques, battle strategies, and defense technologies, and their relevance in contemporary military science and national defense planning.

Note: Depending on the requirement of each laboratory experience, micro project and research-based problems, the performance may be conducted in online/offline mode and accordingly appropriate assessment tools may be used.

L) Suggested Term Work (TW):

a. Assignment(s):

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

i. Comparative Study of Ayurveda and Modern Medicine

- Objective: Compare the principles of Ayurveda with modern medicine in the treatment of common diseases.
- Assignment: Select a particular health issue (e.g., diabetes, hypertension) and compare Ayurvedic approaches with modern medical treatments. Discuss the strengths and limitations of both systems.

ii. Contributions of Ancient Indian Mathematicians

- Objective: Explore the contributions of ancient Indian mathematicians like Aryabhata, Bhaskara, and Brahmagupta.
- Assignment: Write a research paper on a specific mathematical concept (e.g., zero, algebra) developed by ancient Indian scholars and its relevance in modern mathematics.

iii. Analysis of Vedic Astronomy and Its Accuracy

- Objective: Understand how ancient Indian astronomers calculated celestial movements.
- Assignment: Analyze a Vedic astronomical text, such as the Surya Siddhanta, and discuss its accuracy in predicting celestial phenomena like solar or lunar eclipses.

iv. Traditional Water Management Systems in India

- Objective: Investigate ancient Indian water management techniques and their sustainability.
- Assignment: Select a traditional water conservation structure (e.g., step wells, tanks) and analyze its design, efficiency, and potential application in addressing modern water scarcity.

v. Impact of Yoga on Mental and Physical Health

- Objective: Explore the benefits of Yoga on mental and physical well-being.
- Assignment: Research the scientific basis of a particular Yoga practice (e.g., pranayama, meditation) and its impact on health, using both ancient texts and modern scientific studies.

vi. Sustainable Agriculture Practices in Ancient India

- Objective: Investigate traditional agricultural methods in ancient India and their relevance today.
- Assignment: Study a specific ancient agricultural practice (e.g., organic farming, crop rotation) and evaluate how it can address current challenges like soil degradation or climate change.

vii. Chandashastra (Prosody) and Its Application in Modern Poetry

- Objective: Understand the significance of Chandashastra in shaping poetic meter and structure.
- Assignment: Select a Vedic meter (chandas) from Chandashastra and compare its structure with modern poetic forms, analyzing similarities and differences.

viii. Study of Natyashastra and Its Influence on Modern Performing Arts

- Objective: Analyze the influence of Natyashastra on modern performing arts.
- Assignment: Research a section of Natyashastra related to drama or dance, and explain how its principles are applied or can be applied in modern theatre or cinema.

ix. Indian Metallurgy: Ancient Innovations and Modern Applications

- Objective: Understand ancient Indian metallurgical practices and their significance.
- Assignment: Study an ancient Indian metallurgical achievement, such as the rust-resistant Iron Pillar of Delhi, and analyze the scientific techniques used. Compare this with modern metallurgical practices.

b. Seminar Topics:

- "Ayurveda: The Ancient Science of Healing in Modern Healthcare"
- "Mathematical Brilliance of Ancient India: Contributions of Aryabhata and Beyond"
- "Vedic Astronomy: Insights from the Cosmos in Ancient India"
- "Sanskrit and Artificial Intelligence: The Linguistic Bridge to Future Technologies"
- "Iron Pillar of Delhi: The Science Behind Ancient Indian Metallurgy"
- "Yoga for Mental Health: A Scientific Exploration of Ancient Practices"
- "Ancient Indian Water Management Systems: Lessons for Sustainable Development"
- "Ethics in the Mahabharata: Leadership Lessons for the Modern World"
- "Vedic Mathematics: Speed and Simplicity in Problem Solving"
- "Natyashastra: The Ancient Indian Treatise on Performing Arts"
- "Logic and Disputation in Ancient India: The Role of Anviksiki"
- "Traditional Indian Agriculture: Pathways to Sustainable Farming"
- "The Science of Consciousness: Vedantic Insights and Modern Neuroscience"
- "Ancient Indian Contributions to Navigation and Maritime Science"
- "Chandashastra: The Science of Prosody in Sanskrit Poetry"
- "Military Strategies of Ancient India: Lessons from the Arthashastra"
- "Environmental Conservation in Ancient Indian Philosophy: Vedic Insights"
- "Traditional Indian Medicine: Exploring the Efficacy of Siddha and Unani Systems"
- "Agricultural Economics in Ancient India: Insights from Arthashastra and Krishi-Parashara"
- "Traditional Indian Knowledge in Climate Change Adaptation"

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

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. 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. To ensure learning, research-based problems may be designed and implemented.

O) Major Equipment, Tools and Software for Laboratory and Research Work: (Not Applicable)

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Introduction to Indian Knowledge System: Concepts and Applications	Archak, K.B. (2012).	Kaveri Books, New Delhi ISBN-13:978-9391818203
2.	Introduction To Indian Knowledge System: Concepts and Applications	Mahadevan, B. Bhat, Vinayak Rajat Nagendra Pavana R.N.	PHI, ISBN: 9789391818203
3.	Glimpse into Kautilya's Arthashastra	Ramachandrudu P. (2010)	Sanskrit Academy, Hyderabad ISBN:9788380171074
4.	"Introduction" in Studies in Epics and Purāṇas, (Eds.)	KM Munshi and N Chandrashekara Aiyer	Bhartiya Vidya Bhavan

b) Online Educational Resources (OER):

1) http://bhavana.org.in
2) www.academia.edu/23254393/Science_in_Ancient_India_-_an_educational_module
3) www.academia.edu/23305766/Technology_in_Ancient_India_-_Michel_Danino
4) www.hamsi.org.nz/http://insaindia.res.in/journals/ijhs.php
5) www.niscair.res.in/sciencecommunication/ResearchJournals/rejour/ijtk/ijtk0.asp
6) www-history.mcs.st-andrews.ac.uk/Indexes/Indians.html
7) Swami Harshananda. "A bird's eye view of vedas". R K Math. Bangalore.,http:// rkmathbangalore. org/Books/ABirdsEyeViewOfTheVedas.pdf.
8) Sanskrit Prosody, https://en.wikipedia.org/wiki/Sanskrit_prosody.
9) Vartak, P.V. (1995). "Veda and Jyotish," Part II, Chapter 2, in Issues in Veda and Astrology, H Pandya (Ed.), pp 65 – 73.

Q) Course Curriculum Developer

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Course Curriculum Detailing- Online Spell -2

A)	**Course Title:** MOOC Creation	Deemed to be University under Distinct Category
B)	**Course Code:** PC03	
C)	**Pre- requisite (s):**	

D) **Rationale:** The exponential growth of online education, accelerated by global digital transformation, has created an unprecedented demand for high-quality Massive Open Online Courses (MOOCs). Engineering professionals are increasingly required to share their expertise through digital platforms, conduct training programs, and contribute to knowledge dissemination on a global scale. This course addresses the critical need to develop competencies in educational technology design, content creation, and online pedagogy. Students will gain practical experience in conceptualizing, designing, developing, and deploying MOOCs that can reach thousands of learners worldwide. The course integrates engineering problem-solving approaches with educational design principles, enabling graduates to create impactful learning experiences in their respective engineering disciplines. The course aligns with Industry 4.0 requirements, where professionals must not only possess technical expertise but also the ability to transfer knowledge effectively through digital mediums. This skill is particularly valuable for careers in academia, corporate training, consulting, and entrepreneurship in the education technology sector.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected toensuretheaccomplishmentoffollowingindustryexpectedcourseoutcomesbythelearners.

Course Outcomes (COs)	Course Outcome Statements
PC03.CO1	Develop a comprehensive MOOC course structure using instructional design principles.
PC03.CO2	Prepare sample e-content lessons.
PC03.CO3	Produce sample digital media content.
PC03.CO4	Upload the MOOC course structure and its components as per the given guidelines on the LMS.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)		
	PO-1 Independently carry out research/ investigation, and development work to solve practical problems.	**PO-2** Write and present a substantial technical report/ document.	**PO-3** Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor's program
PC03.CO1	3	3	3
PC03.CO2	2	2	3
PC03.CO3	2	2	3
PC03.CO4	-	2	2

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
PC03	PC	MOOC Creation	30	-	-	30	60	02	20	30	50	-	-	-	100

H) Course Curriculum Detailing: For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP 2020, unique features like green skills, multidisciplinary aspects, societal connect, IKS, renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Explain the evolution, characteristics, and types of MOOCs. *TSO 1b.* Interpret learner demographics, motivations, and challenges in MOOC environments. *TSO 1c.* Apply instructional design framework and models for MOOC development. *TSO 1d.* Formulate MOOC outcomes. *TSO 1e.* Design the MOOC course structure.	**Unit-1.0 Foundation of MOOC Design** 1.1 History and evolution of MOOCs. 1.2 MOOCs types and their characteristics. 1.3 Role of learning theories in MOOC design. 1.4 Learner psychology in massive open environments. 1.5 Instructional design frameworks and Models – ADDIE, SAM, Advance Organizer. 1.6 MOOC Components. 1.7 Formulating MOOC outcomes. 1.8 Content structuring and organisation	**CO1**
TSO 2a. Explain the philosophy of self-learning material development. *TSO 2b.* Integrate principles of microlearning and media design for content creation. *TSO 2c.* Integrate elements of Dale's Cone of Experience and principles of micro-learning in the development of lessons. *TSO 2d.* Prepare a bank of OER to be integrated into the MOOC. *TSO 2e.* Prepare a lesson/s along with assessment questions and discussion forum statement as per the given guideline	**Unit-2.0 E-Content Lesson Development** 2.1 Philosophy for the development of self-learning material. 2.2 Principles of microlearning and Media design. 2.3 Dale's cone of experience. 2.4 Intellectual Property rights, OER and Creative Commons licenses. 2.5 Designing MCQ and Discussion forum. 2.6 Rubrics for ''Prepare a sample prototype E Content'' 2.7 Sample format/s for the development of lessons mentioned in the course structure.	**CO2**
TSO 3a. Design graphics, animation, presentation and interactive content using media design principles. *TSO 3b.* Create a sample podcast for MOOC. *TSO 3c.* Write a sample video script for the selected MOOC lesson. *TSO 3d.* Write a shooting script. *TSO 3e.* Plan for video production. *TSO 3f.* Present to camera in studio. *TSO 3g.* Edit the video and sound file for finalisation of the sample video.	**Unit-3.0 Digital Media Production** 3.1 Video production pipeline – Video production vocabulary. 3.2 Multi-camera studio production. 3.3 Podcast creation. 3.4 Video script development. 3.5 Graphics design and animation. 3.6 Shooting script development. 3.7 Interactive content creation tools. 3.8 Audio and video editing.	**CO3**
TSO 4a. Describe features of the SWAYAM MOOCs. *TSO 4b.* Design the course structure on ePrashikshan.	**Unit-4.0 MOOC Course Configuration on LMS and its Guidelines**	**CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 4c. Verify that all MOOC components developed adhere to LMS guidelines. *TSO 4d.* Upload MOOC components on ePrashikshan. *TSO 4e.* Test the MOOC course using the pre-launch checklist.	4.1 SWAYAM Guidelines for MOOC development. 4.2 Overview of SWAYAM MOOC structure. 4.3 LMS (ePrashikshan) and its features for MOOC 4.4 LMS-specific guidelines for video duration, file formats, accessibility standards, copyright policies, and assessment requirements 4.5 LMS structure design aspects aligned to course structure (course builder) 4.6 Steps for uploading the MOOC component on LMS 4.7 Steps for publishing MOOC content 4.8 Pre-launch Checklist for LMS - Test all links and embedded media, Review course flow from a learner's perspective, Check quiz functionality and grading settings, test for cross-device and browser compatibility 4.9 Pilot and beta testing	

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems (10 marks- part of term work)

i. Prepare a review paper based on the latest research on the theme related to MOOC design/ delivery/ Assessment of Effectiveness of content/ Effectiveness of activities.
ii. Compare the MOOC course structure of various MOOCs offered on different platforms and present.
iii. Compare different video formats used in various MOOCs offered on different platforms and present.

Note: Depending on the requirement of each laboratory experience, micro project and research-based problems, the performance may be conducted in online/offline mode and accordingly appropriate assessment tools may be used.

L) Suggested Term Work (TW):

a. Assignment(s): A portfolio consisting of the following- (6 Marks each)

- Design of Course Builder and Flyer
- Create a bank of OERs related to the MOOC topic.
- Design of Sample e-content lesson along with SAQs
- Design of Presentation and video recording
- Design of Assessment MCQs for the sample content produced

b. Seminar presentation: Presentation of the MOOC developed in the seminar (10 Marks)

M) Suggested Specification Table for End Semester Theory Assessment (ETA): Questions may be designed based on the higher taxonomy level of cognitive domain.

COs	Relevant Unit Number and Title	Marks
CO1	Unit 1.0 Foundation of MOOC Design	03
CO2	Unit 2.0 E-Content Lesson Development	06
CO3	Unit 3.0 Digital Media Production	15
CO4	Unit 4.0 MOOC Course Configuration on LMS and its Guidelines	06
Total		**30**

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. 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. To ensure learning, research-based problems may be designed and implemented.

O) Major Equipment, Tools and Software for Laboratory and Research Work:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience / Practical Number
1.	Multi-camera studio setup with teleprompter, chroma key set, storage system, lights and audio equipment	Three video cameras set up, HD/ 4K, with Camera Control Unit, Tripod, HD/ 4K recorder, Recording media, Studio lights, different types of microphones and storage system.	All
2.	DSLR Camera setup	Digital HD/ 4K still plus video camera with flash and recording media.	All
3.	Hi-end computer systems	HP Workstation with Intel Core i9 13900 Processor, 32 GB, 1 TB HDD for video editing and graphics preparation.	All
4.	Graphics designing software	Adobe Creative Suite CS 4, Adobe Creative Cloud 2025, Canva	All
5.	Video editing software	Adobe Creative Suite CS 4, Adobe Creative Cloud 2025	All
6.	Sound editing software	Adobe Creative Suite CS 4, Adobe Creative Cloud 2025	All

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	The Cambridge Handbook of Multimedia Learning	Edited by Richard E. Mayer, University of California, Santa Barbara, and Logan Fiorella, University of Georgia	Cambridge University Press, 3rd Edition, Online ISBN: 9781108894333 https://doi.org/10.1017/9781108894333

b) Online Educational Resources (OER):

1) https://storage.googleapis.com/swayam2_central/swayam1/wqimgtest_f8b95943-b963-49b9-85ed-416f2e15d1b4.pdf
2) https://storage.googleapis.com/swayam2_central/swayam1/UGC_Gazette-Credit_Framework_for_Online_Courses_through_SWAYAM.pdf
3) https://storage.googleapis.com/swayam2_central/swayam1/wqimgtest_9da02ba8-bdd8-409c-afdb-645e6dbc544f.pdf
4) https://swayam.gov.in
5) https://pmevidya.education.gov.in/swayam-portal.html
6) https://swayam.inflibnet.ac.in
7) https://spoken-tutorial.org
8) https://epgp.inflibnet.ac.in
9) https://search.creativecommons.org

Q) Course Curriculum Development Team

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A)	**Course Title:** Learner Centric Instructional Methods	Deemed to be University under Distinct Category
B)	**Course Code:** PC04	
C)	**Pre- requisite (s):**	

D) **Rationale:** For planning and implementing a teaching learning session, number of instructional choices are involved, of which one of the vital decisions is regarding the instructional methods to be employed. Learner-centric approaches have proven more effective than traditional teacher-centric methods because they actively engage students in the learning process, empowering them to achieve intended outcomes through meaningful participation. Building on this foundation, Artificial Intelligence has emerged as a transformative force in contemporary education, creating new possibilities for personalized learning, adaptive instruction, and intelligent tutoring systems. This course introduces learners to a comprehensive range of learner centric instructional methods, including these AI-enhanced pedagogical approaches, enabling them to strategically match content with effective delivery strategies. Such alignment becomes particularly valuable for those considering teaching careers in educational institution. Furthermore, the course benefits all learners by equipping them with methods they can immediately apply to enhance their own learning experiences.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following industry expected course outcomes by the learners.

Course Outcomes (COs)	Course Outcome Statements
PC04.CO1	Apply the principles of learning to enhance the effectiveness of instructional process to achieve intended learning outcomes in different domains.
PC04.CO2	Plan to use appropriate instructional method effectively for developing learning outcomes.
PC04.CO3	Interpret the suitability of small group methods to enhance teaching learning effectiveness ensuring learner participation.
PC04.CO4	Devise effective strategy using appropriate learner centred instructional methods and AI tools for a given content.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)		
	PO-1 An ability to independently carry out research /investigation and development work to solve practical problems.	**PO-2** An ability to write and present a substantial technical report/document.	**PO-3** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PC04.CO1	-	2	3
PC04.CO2	2	2	2
PC04.CO3	2	2	2
PC04.CO4	2	2	2

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
PC04	PC	Learner Centric Instructional Methods	30	-	-	30	60	02	30	50	20	-	-	-	100

H) Course Curriculum Detailing: For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP 2020, unique features like green skills, multidisciplinary aspects, societal connect, IKS, renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Justify the need for a variety of instructional methods to attain learning outcomes. *TSO 1b.* Formulate learning outcomes at different taxonomic levels of Cognitive, Affective and Psychomotor domains. *TSO 1c.* Enhance effectiveness of session integrating principles of learning and events of instruction. *TSO 1d.* Classify different types of instructional methods and strategies. *TSO 1e.* Identify potential issues and concerns associated with Teacher centric method *TSO 1f.* Develop an instructional session plan.	**Unit -1.0 Learning Principles and Instructional Methods** 1.1 Learning in different Domains, Learning Outcomes in different domains 1.2 Principles of Learning and Events of Instruction 1.3 Need for Variety of Instructional Methods 1.4 Classification of Instructional Methods and Strategies: Learner Centric and Teacher Centric Methods 1.5 Instruction Session Planning and Implementation	**CO1**
TSO 2a. Use tutorial method effectively. *TSO 2b.* Employ assignment method to develop the pre-determined outcomes. *TSO 2c.* Plan to use laboratory and workshop as an effective instructional method for developing practical skills. *TSO 2d.* Interpret the different techniques of developing workshop related skills. *TSO 2e.* Use project work effectively in teaching-learning situations. *TSO 2f.* Describe how problem-based learning can build critical thinking and reasoning skills.	**Unit-2.0 Interactive and Action Oriented Instructional Methods** 2.1 Question-Answer Technique 2.2 Tutorial Method 2.3 Assignment Method 2.4 Laboratory Work 2.5 Workshop Method 2.6 Project work 2.7 Problem Based Learning	**CO2**
TSO 3a. Use seminar method effectively. *TSO 3b.* Employ case study and group discussion. *TSO 3c.* Explain the strategy to improve the effectiveness of classroom teaching-learning process using Buzz Group method.	**Unit-3.0 Small Group Instructional Methods** 3.1 Seminar Method 3.2 Case Study Method 3.3 Group Discussion 3.4 Buzz Group Session 3.5 Brain Storming Technique	**CO3**
TSO 4a. Describe the principles and advantages of individualized instruction. *TSO 4b.* Explain the need and abilities required for self-learning. *TSO 4c.* Justify the need for variety of ICT Based Techniques for enhancing learning. *TSO 4d.* Explain the way blended and flipped learning approaches can be applied in teaching learning process for improving students' learning. *TSO 4e.* Analyze how AI can enhance effectiveness of instructional sessions.	**Unit-4.0 Online Learning Methods** 4.1 Individualized learning 4.2 Self-Learning 4.3 ICT Based Techniques to enhance Learning (E-learning Platforms: MOOCs, LMS, Educational Apps and Tools, Online Collaboration Tools) 4.4 Applications of AI in Education, AI-powered virtual laboratories 4.5 AI-Powered Personalized Learning Systems: Intelligent Tutoring Systems,	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 4f. Evaluate AI-powered personalized learning systems and their effectiveness.	Adaptive Learning Platforms, AI Chatbots for Education 4.6 Blended and Flipped Learning Approach	

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

a. Perform a literature review on the features and effectiveness of instructional methods that have evolved during recent years.

b. Find out the common barriers perceived in an educational institution in adopting learner-centric instructional strategies.

c. Evaluate the learner satisfaction and motivation, comparing conventional lecture methods and learner-centric approaches

Note: Depending on the requirement of each laboratory experience, micro project and research-based problems, the performance may be conducted in online/offline mode and accordingly appropriate assessment tools may be used.

L) Suggested Term Work (TW):

a. Assignment(s):

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

- Formulate learning outcomes at different taxonomic levels of Cognitive, Affective and Psychomotor domains for an identified course.
- Develop a simple case with brief for an identified course.
- Identify the practical outcomes to be developed through lab experiences for an identified course.
- Identify topics in your area where project method (both minor and major) can be used.
- Prepare instructional session plan for at least three lessons from a selected course.
- Implement the instructional session plan developed in Assignment a4 and upload the recorded video of simulated experience.

b. Seminar Topics:

- Inquiry-Based Learning: Fostering Critical Thinking and Student Investigation
- Theories of Learning
- Learning Styles
- Digital Tools for Student-Centered Education
- Differentiated Instruction process
- Student Self-Assessment
- Gamification and Game-Based Learning
- Experiential Learning: Learning through Direct Experience and Reflection

M) Suggested Specification Table for End Semester Theory Assessment (ETA): Questions may be designed based on the higher taxonomy level of cognitive domain.

COs	Relevant Unit Number and Title	Marks
CO1	Unit-1.0 Learning Principles and Instructional Methods	14
CO2	Unit-2.0 Interactive and Action Oriented Instructional Methods	14
CO3	Unit-3.0 Small Group Instructional Methods	12
CO4	Unit-4.0 Online Learning Methods	10
Total		**50**

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. 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. To ensure learning, research-based problems may be designed and implemented.

O) Major Equipment, Tools and Software for Laboratory and Research Work: (Not Applicable)

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Teaching Strategies: A Guide to Effective Instruction	Orlich, Donald C., Harder, Robert J., Trevisan, Michael S., Brown, Abbie H., and Miller, Darcy E.	Cengage Learning, Eleventh Edition, 2017, ISBN: 978-1305960787
2.	Methods and Techniques of Teaching	Kochhar, S. K.	Sterling Publishers, 2018 ISBN: 978-8120700710
3.	A Taxonomy for Learning, Teaching and Assessing - A revision of Bloom's taxonomy of Educational Objectives	Anderson, L. W., and Krathwohl, D. R.	Pearson Education, First Edition, 2001 ISBN: 978-0801319037
4.	Effective Teaching Methods: Research-Based Practice	Borich, Gary D.	Pearson, Tenth Edition, 2021, ISBN: 978-0136794271
5.	Devise Teaching Strategies and Select Teaching Methods: Module No.2	Banthiya N. K., Earnest Joshua, Mathew Susan S. (Ed.)	TTTI Bhopal, 1999

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
6.	Teaching Strategies: A Guide to Effective Instruction	Donald C. Orlich, Robert J. Harder, Michael S. Trevisan, Abbie H. Brown, Darcy E. Miller	Cengage Learning, 2016, Eleventh Edition, ISBN: 978-1305960787
7.	Advanced Teaching Methods for the Technology Classroom	Petrina, Stephen	IGI Global, 2010, ISBN: 978- 1599043371
8.	Theory and Practice of Case Method of Instruction	Bahttacharya, B.	Excel Books, 2015, ISBN: 9788174465588
9.	Artificial Intelligence in Education: Promises and Implications for Teaching and Learning	Holmes, Wayne, Bialik, Maya, and Fadel, Charles	Center for Curriculum Redesign, 2019, ISBN: 978-1794237111
10.	AI for Teaching and Learning: A Guide for Educators	Chen, Li, Dede, Chris	Harvard Education Press, 2021, ISBN: 978-1682536094

b) Online Educational Resources (OER):

1) http://nufosece.ru/fipofoq.pdf; “Teaching Strategies: A Guide to Better Instruction”
2) http://ro.uow.edu.au/cgi/viewcontent.cgi?article=1413&context=asdpapers; Tools for learning: Technology and teaching strategies Michelle Eady and Lori Lockyer
3) https://onlinecourses.swayam2.ac.in/ntr24_ed52/preview; “Basic Instructional Methods”
4) https://onlinecourses.swayam2.ac.in/ntr24_ed49/preview; “Advanced Instructional Methods”
5) https://nittt.ac.in/modules/Module-4.pdf; “Module 4: Instructional Planning and Delivery”
6) http://unesdoc.unesco.org/images/0010/001095/109590eo.pdf; Delors, J. et al. 1996, Learning: The Treasure Within. Report to UNESCO of the International Commission on Education for the Twenty-First Century. Paris, UNESCO
7) https://www.edx.org/course/artificial-intelligence-in-education; "AI in Education: Fundamentals and Application
8) https://www.coursera.org/specializations/ai-for-teaching-and-learning; "AI for Teaching and Learning Specialization"
9) https://www.unesco.org/en/articles/artificial-intelligence-education-challenges-and-opportunities-sustainable-development; "UNESCO AI in Education Guidelines"
10) https://onlinecourses.swayam2.ac.in/ntr25_ed40/preview, “Integration of Artificial Intelligence in Educational Practices”

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A)	**Course Title:** Intellectual Property Rights (IPR)	Deemed to be University under Distinct Category
B)	**Course Code:** NEP07	
C)	**Pre- requisite (s):**	

D) **Rationale:** Intellectual Property Rights encourage continued creativity and artistic innovation, enriching cultural heritage and promoting diversity in the creative industries by safeguarding the rights of creators and artists under appropriate acts/laws. This course will enable the students to protect their inventions, creative work/assets/product under intellectual property Rights such as patents, copyrights, trademarks, Geographical Indications, Industrial designs, layout of Integrated Circuit design, trade secrets, Traditional knowledge, Plant varieties and Farmer's protection under various IPR laws and acts to succeed in their career and avoid unnecessary litigations.

E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following industry expected course outcomes by the learners.

Course Outcomes (COs)	Course Outcome Statements
NEP07.CO1	Realize the need and significance of Intellectual property (IP), Intellectual Property Rights (IPR) and IPR policy in India.
NEP07.CO2	Protect your innovative product and creative original work under Patent, Copy right, Trademark, Geographical Indication and Plant variety and Farmer's right.
NEP07.CO3	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)					
	PO-1 An ability to independently carry out research /investigation and development work to solve practical problems.	**PO-2** An ability to write and present a substantial technical report/document.	**PO-3** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program	**PO-4** An ability to use different advanced software tools for analysis and design in the field of Green Technology.	**PO-5** An ability to acquire professional and intellectual integrity, ethics of research and an understanding of responsibility to contribute to the community for sustainable development of society.	**PO-6** An ability to engage in life-long learning with a high level of commitment to improve knowledge and competence continuously.
NEP07.CO1	2	2	1	-	2	2
NEP07.CO2	2	2	1	1	2	2
NEP07.CO3	2	2	1	1	2	2

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		Total Marks (TA+TWA+LA)
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
NEP07	NEP	Intellectual Property Rights (IPR)	15	-	-	15	30	01	25	-	25	-	-	-	50

H) Course Curriculum Detailing: For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP 2020, unique features like green skills, multidisciplinary aspects, societal connect, IKS, renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO 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.* With the example of any product explain how the IPR is enforced on a product *TSO 1d.* Name the Legislations Covering different types of IPRs in India. *TSO 1e.* Explain the need and significance of IPR policy in an Institution. *TSO 1f.* Differentiate between limited and unlimited IP with examples	**Unit-1.0 Introduction to IP, IPR and its enforcement** 1.1 IP and IPR – Concept, need and its significance 1.2 Types of IPR – Patent, Copyright, Trademark, Geographical Indications, Industrial designs, Layout design of Integrated Circuit, trade secret, Traditional knowledge, Plant varieties and farmer's rights 1.3 Enforcement of IP on a given product, Overlapping rights 1.4 Legislations Covering IPRs in India 1.5 IPR Policy – Need and significance 1.6 Limited life and Unlimited life IPS	**CO1**
TSO 2a. Explain the need and significance of patent/Copyright/GI/ Plant variety and farmer's right/Traditional knowledge *TSO 2b.* Enlist the criteria for protection under patent/Copyright/GI/ Plant variety and farmer's right/Traditional knowledge *TSO 2c.* List the work protected under patent/Copyright/GI/ Plant variety and farmer's right/Traditional knowledge *TSO 2d.* Mention the legislation set up in India and fees applicable for getting Patent/Copyright/GI/ Plant variety and farmer's right. Also mention the tenure of protection *TSO 2e.* Describe in brief every step of process of patenting/Copyright /GI with the help of a flowchart	**Unit-2.0 Patent, Copyright and related rights, Geographical Indications, Plant Varity and farmer's right, Traditional knowledge** 2.1 Patent - Need and significance of patent, patentable and non-patentable inventions, types of Patent, tenure, legislation and organization set up in India, fees and brief procedure of patent filling in India indicating every step, Infringement, Commercialization of a patent. 2.2 Copyright and related rights - Need and significance of Copyright and related rights, entitlement to protection of copyright, works protected, tenure, legislation and organization set up in India, role of Copyright Board, copy right society, assignment and licensing, fees, brief procedure and infringement. 2.3 Geographical Indications (GI)- Need and significance of GI, entitlement to protection of GI, works protected, classes of GI, tenure, legislation and organization set up in India and fees, Passing and infringement of GI. 2.4 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. 2.5 Traditional knowledge (TK) – Significance, Agreement on TK and its protection.	**CO2**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 3a. Explain the need and significance of Industrial Design/ Layout design of Integrated Circuit/Trademark/Trade secret. *TSO 3b.* Enlist the criteria for protection under of Industrial Design/ Layout design of Integrated Circuit/ Trademark/Trade secret. *TSO 3c.* List the work protected under Industrial Design/ Layout design of Integrated Circuit/Trademark/Trade secret. *TSO 3d.* Mention the legislation set up in India, fees, tenure infringement and remedies applicable for getting Industrial 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	**Unit-3.0 Layout design of Integrated Circuits Industrial Designs, Trademark and Trade secrets,** 3.1 Layout design of Integrated Circuits - Need and significance of protection of layout designs for Integrated Circuits. entitlement to protection, works protected, tenure, legislation and organization set up in India and fees, and Infringement. 3.2 Industrial Designs - Need and significance of Industrial Designs, entitlement to protection of designs, works protected, tenure, who can apply, legislation and organization set up in India and fees, Infringement of design right. 3.3 Trademark – Need and significance, Types of trademark**,** entitlement to protection of trademark, tenure, legislation and organization set up in India and fees, who can apply, Procedure for filing application for Trademark, Passing and infringement of trademark. 3.4 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.	**CO3**

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

Note: Depending on the requirement of each laboratory experience, micro project and research-based problems, the performance may be conducted in online/offline mode and accordingly appropriate assessment tools may be used.

L) Suggested Term Work (TW):

a. Assignment(s):

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

- 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.

- Mr. Ram has created and designed an innovative website. Analyze the appropriate protection mechanism/s for that website.
- Is certification mark different from collective mark? Analyze and answer
- Who can register geographical indication in India?
- Is it possible to register the shape and configuration of a shock absorber under Industrial Design act in India? Analyze and answer
- What is the need of protection of IC Layout design?
- Differentiate between assignment and licensing in case of Copyright.
- Whether attributes of patented product can be protected by trade-secret? Analyze and answer
- Describe strategies used to protect trade secrets in Research Organizations and software companies.

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

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. 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. To ensure learning, research-based problems may be designed and implemented.

O) Major Equipment, Tools and Software for Laboratory and Research Work: (Not Applicable)

P) 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.	Notion Press, 1 January 2017 ISBN-10 1946556319 ISBN-13 978-1946556318
2.	Intellectual Property Law	Narayan P.	Eastern Law House Private Ltd 1 January 2001, ISBN-10 8171772684 ISBN-13 978-8171772681
3.	Intellectual Property Rights: Text and Cases	Radhakrishnan R., Balasubramanian S	Excel Books July 30, 2008 July 30, 2008, ISBN-10: 8174466096 ISBN-13: 978-8174466099
4.	Law Relating to Intellectual Property	Wasehra B. L	Universal Law Publishing January 2016, 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 (OER):

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

Others:

1) E book - https://dst.gov.in/sites/default/files/E-BOOK%20IPR.pdf
2) WIPO Intellectual Property Handbook
3) The Intellectual Property Handbook: A Practical Guide for Franchise, Business, and IP
4) Counsel Second Edition by Christopher P. Bussert, James R. Sims III
5) IPR Handbook for Pharma Students and Researchers Parikshit Bansal, Pharma Med Press, 2015
6) https://www.kaggle.com/rohankayan/years-of-experience-and-salary-dataset

Q) Course Curriculum Developer

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16. Annexure

16.1 Common Courses across the all M. Tech., MBA and M.Sc. programmes

S. No.	Common Courses Title
1.	Basics of Artificial Intelligence and Machine Learning
2.	Sports, Yoga & Meditation
3.	Open Educational Resources
4.	Professional Ethics
5.	Financial Literacy
6.	Engineering Economics
7.	Project
8.	Research Methodology
9.	Curriculum & Assessment
10.	Indian Knowledge System (IKS)
11.	Dissertation Part -I
12.	Dissertation Part - II
13.	MOOC Creation
14.	Learner Centric Instructional Methods
15.	Intellectual Property Rights (IPR)

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