Curriculum
of
M.Sc. Programme
In

Physics
(Semiconductor Science and Technology)

Deemed to be University under
Distinct Category

August, 2025

National Institute of Technical Teachers' Training & Research
(NITTTR), Bhopal
(Deemed to be University under Distinct Category)
Ministry of Education, Government of India
Shamla Hills, Bhopal (M.P.) 462 002
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Contents

S. No.			Page Nos.
1.	**Preface**		**I**
2.	**Introduction**		**II**
3.	**Approach for Scientific Design & Development of Curriculum**		**II**
4.	**Unique Features of the Curriculum**		**III**
5.	**Vision and Mission Statement of the Institute**		**IV**
6.	**Vision and Mission of the Department**		**V**
7.	**Programme Educational Objectives (PEOs)**		**V**
8.	**Programme Outcomes (POs)**		**V**
9.	**Employment Potential**		**VI**
10.	**Features of M.Sc. in Physics (Semiconductor Science and Technology)**		**VI**
11.	**Programme Structure (PS) with Teaching & Learning and Assessment Scheme**		**VII**
12.	**Course Curriculum Detailing- Offline Spell -1**		**1**
	12.1	Mathematical Physics	**2**
	12.2	Quantum Mechanics	**8**
	12.3	Solid State Physics	**14**
	12.4	Physics of Semiconductor Devices	**21**
	12.5	Basics of Artificial Intelligence and Machine Learning	**28**
	12.6	Sports, Yoga & Meditation	**39**
	12.7	Open Educational Resources	**47**
	12.8	Professional Ethics	**52**
	12.9	Financial Literacy	**57**
	12.10	Engineering Economics	**63**
13.	**Course Curriculum Detailing- Offline Spell -2**		**71**
	13.1	Semiconductor Materials and their Applications	**72**
	13.2	Semiconductor Processing and Fabrication	**78**
	13.3	Nanoscience and Technology	**85**
	13.4	Laser Physics and its Application	**91**
	13.5	Electronics Circuits and Systems	**99**
	13.6	Project	**107**
14.	**Course Curriculum Detailing- Online Spell -1**		**114**
	14.1	Research Methodology	**115**
	14.2	Curriculum & Assessment	**121**
	14.3	Indian Knowledge System (IKS)	**128**
15.	**Course Curriculum Detailing- Online Spell -2**		**135**
	15.1	MOOC Creation	**136**
	15.2	Learner Centric Instructional Methods	**142**
	15.3	Intellectual Property Rights (IPR)	**148**
16.	**Annexure**		**XIV**
	16.1	Common Courses across the all M. Tech., MBA and M.Sc. programmes	**XIV**

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.

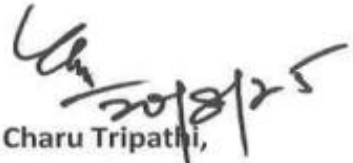
It is to mention here with great pride and immense pleasure that NITTTR Bhopal has launched 05 M. Tech. programmes in engineering, one MBA programme,2 MSc programmes. 09 PG Diploma and 03 diploma programmes from 2025-26. Two batches have already been passed out in the Diploma in Semiconductor Packaging (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.Sc. in Physics (Semiconductor Science and Technology) program is designed to meet the increasing demand for professionals proficient in Physics and semiconductor science and technology. The rationale behind this program is to equip students with the necessary knowledge related to physics, semiconductor materials and photonics and technologies ranging from silicon to compound semiconductors, including emerging fields like plastic electronics and 2D materials. This course equips students with the skills to design and manufacture semiconductor devices and gain insights into the diverse applications of these technologies, spanning areas such as communications, artificial intelligence, automotive and photonics.

Semiconductor device fabrication and processing, semiconductor theory and materials and applications, device/materials characterization, Micro-Electrical Systems (MEMS), plastic electronics, device testing and characterization, and applications (communications, AI, automotive, photonics, energy-efficient devices, and sensors).

The semiconductor revolution will create thousands of new jobs over the next five years and many more in the decades to come. The M. Sc. in Physics (Semiconductor Science and Technology) will prepare students in Physics, Chemistry, Mathematics, Electronics and communication Engineering for careers in semiconductor and related industries and equip them with transferable skills for many other sectors.

The development and testing of Semiconductor assembly technology require a multidisciplinary approach that integrates knowledge and skills from various fields, such as physics, electronics, chemistry, and therefore, there is a high demand for qualified professionals who can contribute to the innovation and advancement in semiconductor science and technology.

This M. Sc. in Physics (Semiconductor Science and Technology) is a two-year full-time program that aims to provide students with a comprehensive and in-depth understanding of the principles and practices of semiconductor science. The program also aims to develop students' research and analytical skills and their professional and ethical competencies to prepare them for careers in the semiconductor industry, academia, or government agencies.

The curriculum includes courses to develop professional-specific skills in the technology domain and pedagogy in each spell, including the Capstone project. Students have the option to choose courses from the list of Professional Elective Courses to develop professional skills related to the area of big data analytics. Similarly, they can choose courses of their liking from the list of skill Enhancement courses to develop their specialisation in the given area. Each student can choose his/her pathway to completing the program through these program electives and special electives.

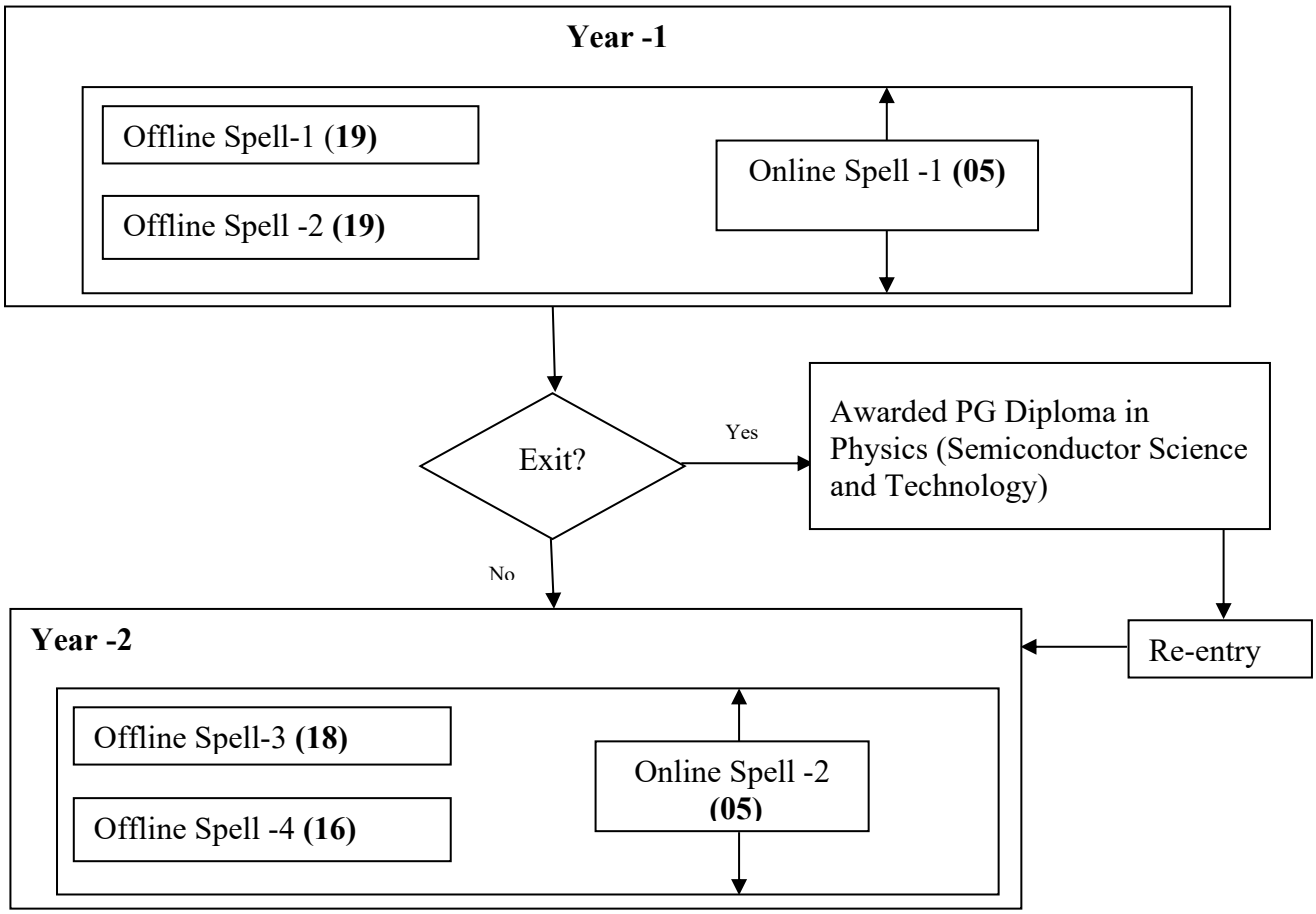
3. Approach for Scientific Design & Development of Curriculum:

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: To develop a department of applied science education as a centre of excellence to promote innovations, research & development, and applied science education-based training to impart new knowledge for applied science and engineering applications.

Mission:

- Launch demand-based long-term and short-term applied science education and training programs.
- Undertake curriculum development in emerging areas of applied science at discipline /course /topic levels to bring about need-based and qualitative change in applied science focused on engineering applications.
- Develop need-based, specific, innovative instructional resources for effective teaching and training in applied science education
- Undertake research in the area of applied sciences, engineering education and training.
- Enhance international outreach through various linkages with other organisations and agencies.

7. Programme Educational Objectives (PEOs):

PEO1: Be a successful professional in educational institutions.

PEO2: Be a successful professional in the semiconductor industries/ research & other organisations.

PEO3: Pursue higher studies and continue their professional development.

PEO4: Provide product solutions using state-of-the-art technologies.

PEO5: Be a successful entrepreneur who provides services in the semiconductor and allied areas.

8. Programme Outcomes (POs): -

PO-1 Demonstrate the acquisition of procedural knowledge required for performing and accomplishing complex and specialised and professional tasks relating to teaching, research and development.

PO-2 Demonstrate the acquisition of advanced cognitive and technical skills required for evaluating research findings and designing and conducting research in Semiconductor Science.

PO-3 Apply advanced knowledge relating to research methods to carry out research and investigations to formulate evidence-based solutions to complex and unpredictable problems in semiconductor science and technology.

PO-4 Communicate, in a well-structured manner, technical information and explanations, and the findings/results of the research studies undertaken in the field of semiconductor science and technology, by following basic research ethics

9. Employment Potential:

Sample Employment and self-employment avenues are mentioned below-

9.1. Employment Avenues:

- Academician
- Scientist
- Semiconductor Process Engineer
- Research and Development Engineer in semiconductor
- Semiconductor Packaging Engineer
- Semiconductor Device Engineer
- Product Engineer (Semiconductor)

9.2. Self-Employment Avenues:

- Product Development and Prototyping
- Semiconductor Startups
- Training and Education
- Research and Development (R&D) in the area of Semiconductors
- Consultant for the Semiconductor industry.

10. Features of MSc in Physics (Semiconductor Science and Technology)

The M.Sc. Programme in Physics with Specialization in Semiconductor Science and Technology is carefully structured in alignment with the objectives of India's Semiconductor Mission, which aims to establish a resilient and self-sustaining semiconductor ecosystem within the country. This programme is envisioned to prepare a technically competent workforce capable of contributing to key segments such as Assembly, Testing, Marking, and Packaging (ATMP) and Outsourced Semiconductor Assembly and Test (OSAT) units, which are central to the nation's semiconductor value chain.

The programme is supported by well-equipped laboratories with advanced characterisation tools, simulation software, and experimental setups focused on semiconductor device physics, materials, and fabrication processes. These facilities enable hands-on exposure to emerging technologies and bridge the gap between fundamental physics and applied semiconductor science.

What distinguishes this programme is its strategic alignment with the core mandate of NITTTR Bhopal—curriculum development, pedagogy, and technical teacher training. Along with advanced domain knowledge, the programme integrates pedagogical training, thereby developing not only competent semiconductor professionals but also future-ready educators and academic leaders. This dual emphasis ensures meaningful contribution towards India's vision of becoming an Atmanirbhar Bharat in semiconductor technology and scientific education.

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

1.	**Title of Programme**	:	M.Sc. Programme in Physics (Semiconductor Science and Technology)
2.	**Board of Studies**	:	Physics (Semiconductor Science and Technology)
3.	**Duration of Programme**	:	Two Years
4.	**Entry Qualification**	:	B.Sc. (PCM, Physics, Electronics) B. Tech. (Electronics and Allied Branches)
5.	**Total Marks**	:	3690
6.	**Total Credits**	:	82
7.	**Total Number of Courses**	:	22

Summary of Credits and Marks

S. No	Spell	Credits	Total Marks
Year -1			
1.	Offline Spell - 1	19	800
2.	Offline Spell –2	19	780
3.	Online Spell – 1 (PD& NEP)	05	250
Total		**43**	**1830**
Year-2			
4.	Offline Spell - 3	18	810
5.	Offline Spell - 4	16	800
6.	Online Spell – 2 (PD & NEP)	05	250
Total		**39**	**1860**
Grand Total		**82**	**3690**

Category wise Courses

S. No.	Course Category	Abbreviations	Number of Courses	Total Credits
1.	Programme Core Courses	PCC	08	28
2.	Programme Elective Courses	PEC	03	11
3.	Stream Specific Diversified Courses (if applicable)	SSC	-	-
4.	Open Elective Courses (Common Basket)	OEC	01	03
5.	Project, Dissertation	PD	03	29
6.	Pedagogy Courses	PC	04	08
7.	NEP Courses	NEP	03	03
Total			**22**	**82**

M.Sc. - Physics (Semiconductor Science and Technology)- MSCPST

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)		
MSCPST01	PCC	**Mathematical Physics**	30	15	-	45	90	03	30	50	40	-	-	-		120
MSCPST02	PCC	**Quantum Mechanics**	30	15	45	30	120	04	30	50	40	-	20	30		170
MSCPST03	PCC	**Solid State Physics**	30	15	45	30	120	04	30	50	40	-	20	30		170
MSCPST04 (VMEL01)	PCC	**Physics of Semiconductor Devices**	30	15	-	45	90	03	30	70	20	-	-	-		120
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 Course**	15	-	-	15	30	01	25	-	25	-	-	-		50
Total			**165**	**75**	**135**	**195**	**570**	**19**	**175**	**290**	**185**	**-**	**60**	**90**		**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)

* **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)	
MSCPST05	PCC	**Semiconductor Materials and their Applications**	30	15	-	45	90	03	30	50	40	-	-	-	120
MSCPST06	PCC	**Semiconductor Processing and Fabrication**	30	15	45	30	120	04	30	50	40	-	20	30	170
MPCPST07	PCC	**Nanoscience and Technology**	30	15	-	45	90	03	30	50	40	-	-	-	120
MSCPST08-09	PEC	**Programme Elective Courses -1**	30	15	45	30	120	04	30	50	40	-	20	30	170
PD01	PD	**Project**	-	-	45	105	150	05	-	-	200	-	-	-	200
Total			**120**	**60**	**135**	**255**	**570**	**19**	**120**	**200**	**360**	**-**	**40**	**60**	**780**

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 Courses -1: Laser Physics and its Applications (MSCPST08)/ Electronics Circuits and Systems (MSCPST09)

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)	
MSCPST 10-11	PEC	**Programme Elective Courses -2**	30	15	45	30	120	04	30	50	40	-	20	30	170
MSCPST 12-13	PEC	**Programme Elective Courses -3**	45	15	-	30	90	03	30	50	40	-	-	-	120
MSCPST	OEC	**Open Elective Courses -1**	45	15	-	30	90	03	30	70	20	-	-	-	120
PD02	PD	**Dissertation Part -I**	-	-	90	150	240	08	-	-	300	100	-	-	400
Total			**120**	**45**	**135**	**240**	**540**	**18**	**90**	**170**	**400**	**100**	**20**	**30**	**810**

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 Courses -2: Semiconductor Packaging (VMEL04/ MSCPST10)/ Electrodynamics (MSCPST11)
Programme Elective Courses -3: Flexible Electronics (VMEL17)/MSCPST12)/ Plasma Physics (MSCPPST13)

Open Elective Courses -1: Learners may also opt Open Elective Course offered by other PG programmes as well as from any category of the courses of the same spell/ MOOC 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

S. No.	Course Codes	Course Titles	Page No.
1.	MSCPST01	Mathematical Physics	2
2.	MSCPST02	Quantum Mechanics	8
3.	MSCPST03	Solid State Physics	14
4.	MSCPST04 (VMEL01)	Physics of Semiconductor Devices	21
5.	CSEB05	Basics of Artificial Intelligence and Machine Learning	28
6.	NEP01-05	NEP Course	39

A)	**Course Title:** Mathematical Physics
B)	**Course Code:** MSCPST01
C)	**Pre- requisite (s):** Elementary calculus and linear algebra

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D) Rationale: Modern semiconductor research and applications require mathematical modelling and computational analysis. This course provides essential mathematical tools and computational skills needed for advanced study in semiconductor physics and technology. The course integrates AI/ML applications in semiconductor design and analysis, enhancing students' ability to solve complex problems through advanced mathematical methods, computational approaches, and AI/ML techniques.

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
MSCPST01.CO1	Analyse Physical systems using vector calculus and tensor mathematics
MSCPST01.CO2	Analyse semiconductor defects using complex analysis and tensor mathematics
MSCPST01.CO3	Apply advanced mathematical methods to solve complex differential equations.
MSCPST01.CO4	Integrate linear algebra and Fourier analysis approaches semiconductor device optimization
MSCPST01.CO5	Implement numerical methods and programming techniques to simulate semiconductor device behaviour

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)			
	PO-1 Demonstrate the acquisition of procedural knowledge required for performing and accomplishing complex and specialised and professional tasks relating to teaching, research and development.	**PO-2** Demonstrate the acquisition of advanced cognitive and technical skills required for evaluating research findings and designing and conducting research in Semiconductor Science.	**PO-3** Apply advanced knowledge relating to research methods to carry out research and investigations to formulate evidence-based solutions to complex and unpredictable problems in semiconductor science and technology.	**PO-4** Communicate, in a well-structured manner, technical information and explanations, and the findings/results of the research studies undertaken in the field of semiconductor science and technology, by following basic research ethics
MSCPST01.CO1	3	3	2	2
MSCPST01.CO2	3	3	2	2
MSCPST01.CO3	3	3	2	2
MSCPST01.CO4	3	3	2	2
MSCPST01.CO5	3	3	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)	
MSCPST01	PCC	Mathematical Physics	30	15	-	45	90	03	30	50	40	-	-	-	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. Apply vector operations to physical problems in semiconductor physics. *TSO 1b.* Solve problems using tensor calculus. *TSO 1c.* Utilize vector differential operators in semiconductor contexts.	**Unit-1.0 Vector Analysis and Tensor Calculus** 1.1 Vector algebra revisited: dot and cross products 1.2 Vector differential operators: gradient, divergence, curl 1.3 Vector integration: line, surface, and volume integrals 1.4 Tensor analysis for semiconductor materials 1.5 Applications in semiconductor physics: crystal structures and transport phenomena	**CO1**
TSO 2a. Apply complex analysis techniques to solve semiconductor-related problems *TSO 2b.* Use residue theorem and conformal mapping in device modelling. *TSO 2c.* Implement complex functions in computational modeling.	**Unit-2.0 Complex Analysis** 2.1 Complex variables and functions 2.2 Analytic functions and Cauchy-Riemann conditions 2.3 Complex integration and Cauchy's theorem 2.4 Residue theorem and applications 2.5 Conformal mapping in semiconductor device design 2.6 Complex pattern recognition for semiconductor defect analysis	**CO2**
TSO 3a. Create Solve ODEs and PDEs relevant to semiconductor physics. *TSO 3b.* Apply Green's function techniques to boundary value problems. *TSO 3c.* Implement numerical methods for differential equations.	**Unit-3.0 Differential Equations** 3.1 Ordinary differential equations: series solutions and special functions 3.2 Partial differential equations: separation of variables 3.3 Boundary value problems in semiconductor devices 3.4 Green's functions and integral equations 3.5 Numerical solutions for semiconductor transport equations	**CO3**
TSO 4a. Apply linear algebra concepts to semiconductor physics problems. *TSO 4b.* Utilize Fourier and related transforms for signal analysis. *TSO 4c.* Implement matrix methods for semiconductor system modelling	**Unit-4.0 Linear Algebra and Fourier Analysis** 4.1 Matrix theory and eigenvalue problems 4.2 Linear transformations and diagonalization 4.3 Fourier series and transforms in semiconductor signal processing 4.4 Laplace and Z-transforms 4.5 Wavelet analysis for semiconductor signal processing	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 5a. Develop algorithms for numerical solutions in semiconductor physics. *TSO 5b.* Implement computational techniques using SCILAB/MATLAB. *TSO 5c.* Apply optimization methods to semiconductor design problems.	**Unit -5.0: Numerical Methods and Programming** 5.1 Programming fundamentals: MATLAB/ SCILAB 5.2 Numerical integration and differentiation techniques 5.3 Numerical solutions of ODEs and PDEs in the semiconductor context 5.4 Optimisation methods for semiconductor device design 5.5 Data visualisation and analysis techniques 5.6 Implementation of optimisation algorithms for semiconductor parameter tunning	**CO5**

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

i. Develop a mathematical model integrating tensor calculus and machine learning to predict properties of novel semiconductor materials.
ii. Create a computational framework combining differential equations and neural networks to simulate quantum transport phenomena in semiconductor nanowires.
iii. Design an AI-based system using complex analysis and convolution neural networks for identifying and classifying defects in semiconductor wafers.
iv. Design an AI-based system using complex analysis and convolution neural networks for identifying and classifying defects in semiconductor wafers.
v. Create a wavelet-based signal processing system enhanced with machine learning for noise reduction in semiconductor measurements.
vi. Explore how ancient Indian mathematical principles (like those found in Vedic mathematics) can be applied to optimize modern computational algorithms for semiconductor simulations

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:

- Modelling in Xcos and Simulink
- Data Visualisation using SCILAB/MATLAB
- Semiconductor data analysis 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 Vector Analysis and Tensor Calculus	10
CO2	Unit 2.0 Complex Analysis	08
CO3	Unit 3.0 Differential Equations	09
CO4	Unit 4.0 Linear Algebra and Fourier Analysis	11
CO5	Unit 5.0 Numerical Methods and Programming	12
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.	Mathematical Methods for Physicists	Arfken, Weber, and Harris,	Academic Press, ISBN: 978-0123846549
2.	Mathematical Physics: A Modern Introduction to Its Foundations	Sadri Hassani,	Springer ISBN: 978-3319011950
3.	Numerical Recipes: The Art of Scientific Computing	Press, Teukolsky, Vetterling, and Flannery,	Cambridge University Press, ISBN: 978-0521880688

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
4.	Mathematics for Machine Learning,	Deisenroth, Faisal, and Ong	Cambridge University Press, ISBN: 978-1108455145

b) Online Educational Resources (OER):

1) https://Engineers:https://ocw.mit.edu/courses/mathematics/18-086-mathematical-methods-for-engineers-ii-spring-2006/
2) https://www.coursera.org/learn/machine-learning

Q) Course Curriculum Developer

S. No.	Name	E-mail Address
1.	Prof. Hussain Jeevakhan	hjeevakhan@nitttrbpl.ac.in

****

A)	**Course Title:** Quantum Mechanics
B)	**Course Code:** MSCPST02
C)	**Pre- requisite (s):** Mathematical Methods, Classical mechanics and electromagnetism

Deemed to be University under Distinct Category

D) **Rationale:** Quantum mechanics forms the theoretical foundation for understanding semiconductor physics and technology at the atomic and subatomic levels. This course provides the essential quantum mechanical principles needed to comprehend semiconductor behaviour, band structure, tunnelling phenomena, and quantum confinement effects that are fundamental to modern semiconductor devices. By integrating AI/ML approaches with quantum mechanical principles, students will develop advanced skills for modelling and simulating quantum systems relevant to semiconductor technology, preparing them for research and industry careers in this rapidly evolving field

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
MSCPST02.CO1	Apply quantum mechanical principles to solve problems related to semiconductor physics and technology.
MSCPST02.CO2	Derive quantum mechanical models to explain electron behaviour in semiconductor materials and devices.
MSCPST02.CO3	Analyse quantum mechanical systems using computational methods and AI/ML techniques.
MSCPST02.CO4	Evaluate quantum mechanical approximation methods for semiconductor applications
MSCPST02.CO5	Design semiconductor devices based on quantum mechanical principles

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)			
	PO-1 Demonstrate the acquisition of procedural knowledge required for performing and accomplishing complex and specialised and professional tasks relating to teaching, research and development.	**PO-2** Demonstrate the acquisition of advanced cognitive and technical skills required for evaluating research findings and designing and conducting research in Semiconductor Science.	**PO-3** Apply advanced knowledge relating to research methods to carry out research and investigations to formulate evidence-based solutions to complex and unpredictable problems in semiconductor science and technology.	**PO-4** Communicate, in a well-structured manner, technical information and explanations, and the findings/results of the research studies undertaken in the field of semiconductor science and technology, by following basic research ethics
MSCPST02.CO1	3	3	2	1
MSCPST02.CO2	3	3	2	1
MSCPST02.CO3	3	3	2	1
MSCPST02.CO4	3	3	2	1
MSCPST02.CO5	3	3	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)						
			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)	
MSCPST02	PCC	Quantum Mechanics	30	15	45	30	120	04	30	50	40	-	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 quantum mechanical postulates and their implications. *TSO 1b.* Apply Schrödinger equation to simple quantum systems. *TSO 1c.* Analyze the mathematical framework of quantum mechanics.	**Unit-1.0 Fundamentals of Quantum Mechanics** 1.1 Quantum mechanics postulates and mathematical framework 1.2 Wave-particle duality and the Schrödinger equation 1.3 Wave functions, observables, and measurement 1.4 Quantum states and operators 1.5 Heisenberg uncertainty principle	**CO1**
TSO 2a. Solve quantum mechanical problems in 1D potentials. *TSO 2b.* Analyze quantum tunnelling phenomena. *TSO 2c.* Apply quantum principles to semiconductor quantum wells	**Unit-2.0 One-Dimensional Quantum Systems** 2.1 Infinite and Finite Potential wells 2.2 Quantum tunneling phenomena 2.3 Potential barriers and quantum transport 2.4 Harmonic oscillator 2.5 Applications in semiconductor quantum wells	**CO2**
TSO 3a. Solve the Schrödinger equation for 3D systems. *TSO 3b.* Apply quantum theory to atomic systems. *TSO 3c.* Analyze angular momentum in quantum mechanical systems.	**Unit-3.0 Three-Dimensional Quantum Systems** 3.1 Functions: 3D Schrödinger equation and separable potentials 3.2 Hydrogen atom and atomic orbitals 3.3 Angular momentum in quantum mechanics 3.4 Quantum numbers and selection rules 3.5 Applications to semiconductor atoms and defects	**CO3**
TSO 4a. Analyse band structure using quantum mechanical principles. *TSO 4b.* Apply structure calculations, effective mass theory to semiconductor systems. *TSO 4c.* Implement k·p method for band.	**Unit-4.0 Quantum Mechanics of Solids** 4.1 Bloch theorem and band structure 4.2 Tight-binding model 4.3 Electron states in periodic potentials 4.4 Effective mass theory 4.5 k·p method for semiconductor band structure	**CO4**
TSO 5a. Analyse quantum confinement effects in semiconductor nanostructures. *TSO 5b.* Evaluate quantum phenomena in modern semiconductor devices. *TSO 5c.* Apply quantum principles to emerging semiconductor technologies.	**Unit -5.0: Advanced Quantum Phenomena in Semiconductors** 5.1 Quantum confinement in nanostructures 5.2 Quantum dots, wires, and wells 5.3 Quantum Hall effect 5.4 Spin-orbit coupling and spintronics	**CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
	5.5 Quantum computing concepts for semiconductors	

J) Suggested Laboratory Experiences:

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
LSO 1.1 Implement numerical solutions for quantum systems. *LSO 1.2* Visualize quantum wave functions and probability densities.	1.	Quantum State Simulation: Numerical solutions to Schrödinger equation for various potentials	CO-1
LSO 2.1 Simulate quantum tunnelling through potential barriers. *LSO 2.2* Analyze tunnelling probabilities in semiconductor contexts.	2.	Quantum Tunnelling Lab: Computational investigation of tunnelling phenomena.	CO-1
LSO 3.1 Calculate band structures using quantum mechanical methods. *LSO 3.2* Analyze band properties for different semiconductor material.	3.	Band Structure Calculation: Implementation of tight binding and k·p methods	CO-1, CO-2
LSO 4.1 Model quantum confinement in nanostructures. *LSO 4.2* Analyze electronic states in quantum dots and wells.	4.	Quantum Dots Simulation: Modelling of quantum confinement effects.	CO-1, CO-2
LSO 5.1 Apply machine learning techniques to quantum mechanical problems.	5.	Quantum ML Lab: Application of ML algorithms to quantum problems	CO-1, CO-2
LSO 6.1 Simulate quantum transport in semiconductor devices	6.	Quantum Transport Simulation: Computational exploration of quantum transport phenomena in semiconductors	CO-1, CO-2

K) Suggested Research Based Problems

i. Design a Quantum Machine Learning for Material Discovery: Develop a machine learning framework that combines quantum mechanical principles with deep learning to predict properties of novel semiconductor materials.
ii. Quantum Transport Optimization: Create an AI-enhanced computational model to optimize quantum transport in semiconductor nanostructures for improved device performance.
iii. Defect Engineering via Quantum Mechanics: Design a hybrid quantum-classical algorithm for identifying and engineering beneficial defects in semiconductor materials.
iv. Quantum Tunnelling Enhancement: Develop models using quantum principles and neural networks to enhance tunnelling phenomena for specific semiconductor applications.
v. Quantum Confinement Engineering: Create a computational framework for designing quantum confined semiconductor structures with tailored electronic properties using evolutionary algorithms.
vi. Spintronics Simulation: Develop quantum mechanical models enhanced by machine learning for simulating and optimizing spin-based semiconductor devices.

vii. Quantum Computing Integration: Design semiconductor-based quantum computing architectures using quantum mechanical principles combined with optimization algorithms.

viii. Vedic Pattern Recognition in Quantum Systems: Investigate parallels between patterns described in ancient Indian mathematical texts and quantum mechanical systems, potentially leading to novel computational 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.

b. Seminar Topics:

- Application of Quantum Mechanics in Semiconductors
- Computational tools for quantum Mechanical systems
- Quantum Computing

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 Quantum Mechanics	10
CO2	Unit 2.0 One-Dimensional Quantum Systems	10
CO3	Unit 3.0 Three-Dimensional Quantum Systems	11
CO4	Unit 4.0 Quantum Mechanics of Solids	09
CO5	Unit 5.0 Advanced Quantum Phenomena in Semiconductors	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:

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.	Computational Software: MATLAB with Quantum Mechanics	High-level technical computing software used for numerical computation, data analysis, visualisation, and algorithm development. It should support matrix-based programming, toolboxes for Quantum Mechanics processing and machine learning.	All
3.	Simulation Tools: COMSOL Multiphysics with Quantum Mechanics Module	Finite element analysis (FEA)-based simulation software for modeling and solving coupled multiphysics problems. It should supports physics interfaces such as Quantum mechanics, and electromagnetics, The software should in include GUI-based model building, integrated solvers, parametric sweeps, optimization, and scripting via COMSOL Script or MATLAB.	All

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Quantum Mechanics for Scientists and Engineers	David A. B. Miller	Cambridge University Press, ISBN: 978-0521897839
2.	Quantum Physics for Scientists and Technologists	Paul Sanghera	Wiley, ISBN: 978-0470922699
3.	Introduction to Quantum Mechanics	David J. Griffiths and Darrell F. Schroeter	Cambridge University Press, ISBN: 978-1107189638
4.	Quantum Mechanics for Applied Physics and Engineering	Albert T. Fromhold	Dover Publications, ISBN: 978-0486667416

b) Online Educational Resources (OER):

1) https://ocw.mit.edu/courses/physics/8-04-quantum-physics-i-spring-2016/
2) https://www.coursera.org/learn/quantum-mechanics-scientists-engineers
3) https://www.physicspython.wordpress.com/category/quantum-mechanics/

Q) Course Curriculum Developer

S. No.	Name	E-mail Address
1.	Prof. Hussain Jeevakhan	hjeevakhan@nitttrbpl.ac.in

****

A)	**Course Title:** Solid State Physics	Deemed to be University under Distinct Category
B)	**Course Code:** MSCPST03	
C)	**Pre-requisite (s):**	

D) **Rationale:** Solid state physics forms the foundation of modern solid-state technology and materials science. This course provides a comprehensive understanding of structural, electronic, and dynamical properties of crystalline and non-crystalline materials. It enables learners to understand the quantum mechanical basis of material properties, phase transitions, and emerging phenomena in solid-state systems. The knowledge gained is essential for advanced research in materials science, nanotechnology, and solid-state device physics.

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
MSCPST03.CO1	Analyse crystal structures using diffraction techniques.
MSCPST03.CO2	Evaluate lattice dynamics, phonon properties, and thermal properties of crystalline solids.
MSCPST03.CO3	Apply the free electron model and band theory to explain the electronic properties of metals and semiconductors.
MSCPST03.CO4	Analyse superconducting phenomena using thermodynamic and microscopic theories.
MSCPST03.CO5	Investigate properties of non-crystalline materials, including glasses, liquid crystals, and polymers

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)			
	PO-1 Demonstrate the acquisition of procedural knowledge required for performing and accomplishing complex and specialised and professional tasks relating to teaching, research and development.	**PO-2** Demonstrate the acquisition of advanced cognitive and technical skills required for evaluating research findings and designing and conducting research in Semiconductor Science.	**PO-3** Apply advanced knowledge relating to research methods to carry out research and investigations to formulate evidence-based solutions to complex and unpredictable problems in semiconductor science and technology.	**PO-4** Communicate, in a well-structured manner, technical information and explanations, and the findings/results of the research studies undertaken in the field of semiconductor science and technology, by following basic research ethics
MSCPST03.CO1	3	3	2	1
MSCPST03.CO2	3	3	2	1
MSCPST03.CO3	3	3	2	1
MSCPST03.CO4	3	3	2	1
MSCPST03.CO5	3	3	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)	
MSCPST03	PCC	Solid State Physics	30	15	45	30	120	04	30	50	40	-	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 scattering theory for X-rays, neutrons, and electrons from crystalline solids *TSO 1b.* Calculate atomic scattering factors and structure factors *TSO 1c.* Analyse crystal structures using Miller indices and reciprocal lattice concepts *TSO 1d.* Apply diffraction conditions to determine crystal parameters.	**Unit-1.0 Crystalline Materials and Diffraction** 1.1 Scattering of X-rays, neutrons and electrons from solids 1.2 Atomic scattering factor and structure factor 1.3 Lattice planes and Miller indices 1.4 Reciprocal lattice and Brillouin zones 1.5 Powder diffraction and single crystal methods	**CO1**
TSO 2a. Apply harmonic and adiabatic approximations to lattice dynamics. *TSO 2b.* Derive dispersion relations for phonons in 3D crystals. *TSO 2c.* Calculate lattice heat capacity using the Einstein and Debye models. *TSO 2d.* Analyse the effects of anharmonicity on thermal expansion.	**Unit 2.0 Lattice Dynamics and Phonons** 2.1 Harmonic and adiabatic approximations 2.2 Lattice vibrations of 3D crystals, periodic boundary conditions 2.3 Normal modes and phonon dispersion relations 2.4 Quantization of lattice vibrations 2.5 Einstein and Debye theories of lattice heat capacity 2.6 Anharmonicity and thermal expansion	**CO2**
TSO 3a. Comprehend the free-electron model to calculate the Fermi energy *TSO 3b.* Analyse electronic heat capacity and transport properties *TSO 3c.* Apply the Bloch theorem to periodic potentials *TSO 3d.* Compare extended and reduced zone schemes *TSO 3e.* Apply the tight-binding model to simple crystal structures.	**Unit-3.0 Electronic Properties and Band Theory** 3.1 Free-electron model: Fermi energy and Fermi surface 3.2 Electronic heat capacity, electrical and thermal conductivity 3.3 Nearly free electron model 3.4 Periodic potential and Bloch theorem 3.5 Extended and reduced zone schemes 3.6 Tight-binding model and energy band	**CO3**
TSO 4a. Analyse experimental evidence for superconductivity *TSO 4b.* Apply thermodynamic analysis to superconducting transitions *TSO 4c.* Derive and apply London equations *TSO 4d.* Comprehend elementary BCS theory and Cooper pairs.	**Unit-4.0 Superconductivity** 4.1 Experimental evidence: Meissner effect, heat capacity jump 4.2 Energy gap and isotope effect 4.3 Thermodynamics of superconductors 4.4 London equations and penetration depth 4.5 Elementary BCS theory and Cooper pairs 4.6 High-temperature superconductors	**CO4**
TSO 5a. Analyse diffraction patterns from non-crystalline solids.	**Unit -5.0: Non-crystalline Materials**	**CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 5b. Investigate quasi-crystalline structures. *TSO 5c.* Apply Landau theory to liquid crystal phase transitions.	5.1 Non-crystalline solids: diffraction patterns 5.2 Glass transition and amorphous state 5.3 Quasi-crystals and forbidden symmetries 5.4 Liquid crystals: orientational order 5.5 Landau theory of isotropic transition 5.6 Physics of polymers: chain statistics and properties	

J) Suggested Laboratory Experiences:

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
LSO 1.1. Simulate X-ray diffraction patterns for different crystal structures.	1.	X-ray Diffraction Simulation and Analysis.	CO1
LSO 2.1. Calculate phonon dispersion relations using computational methods.	2.	Phonon Dispersion Calculations	CO1
LSO 3.1. Plot electronic band structures for simple crystals. *LSO 3.2.* Calculate density of electronic states.	3.	Electronic Band Structure Calculations	CO1, CO2
LSO 4.1. Analyze the temperature dependence of superconducting properties. *LSO 4.2.* Calculate coherence length and penetration depth.	4.	Superconductivity Parameter Analysis	CO1, CO2
LSO 5.1. Use crystallographic software for structure analysis.	5.	Crystallographic Software Applications	CO1, CO2
LSO 6.1. Perform powder X-ray diffraction on crystalline samples *LSO 6.2.* Index diffraction peaks and determine lattice parameters.	6.	Powder X-ray Diffraction	CO1, CO2
LSO 7.1. Measure the electrical resistivity vs temperature of the given semiconductor sample.	7.	Electrical Transport Properties	CO1, CO2
LSO 8.1. Measure magnetic susceptibility of materials	8.	Magnetic Property Measurements	CO1, CO3

K) Suggested Research-Based Problems

i. Investigate electronic band structure of topological insulators using DFT calculations and analyze surface states.
ii. Analyse electronic and mechanical properties of graphene and other 2D materials using computational methods.
iii. Investigate magnetic ordering in transition metal oxides using Monte Carlo simulations.
iv. Analyse electronic structure and optical properties of perovskite materials for photovoltaic applications.
v. Investigate martensitic phase transitions in shape memory alloys using thermodynamic analysis.
vi. Analyze electromagnetic metamaterials with negative refractive index.

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:

- Metamaterials
- Properties of crystalline and amorphous Silicon
- Battery Electrode Materials
- Semiconductor quantum dots

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 Crystalline Materials and Diffraction	10
CO2	Unit 2.0 Lattice Dynamics and Phonons	10
CO3	Unit 3.0 Electronic Properties and Band Theory	12
CO4	Unit 4.0 Superconductivity	10
CO5	Unit 5.0 Non-crystalline Materials	08
Total		**50**

N) Suggested 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 i5, 4 GB RAM, 15 GB free disk space	All
2.	X-ray Diffractometer	Powder and single crystal XRD with Cu Kα source, 2θ range 5-90°, sample stage with heating/cooling	1,6
3.	Four-Point Probe System	Resistivity measurement setup, temperature range 4K-400K, magnetic field capability	7
4.	SQUID Magnetometer	Magnetic susceptibility measurement, 1.8K 400K, ±7T field	8
5.	Differential Scanning Calorimeter	Heat capacity and phase transition studies -180°C to 725°c	2
6.	MATLAB/Octave Software	Numerical computation and data analysis	All
7.	Quantum ESPRESSO	DFT calculations for electronic structure	All
8.	VESTA Software	Crystal structure visualization	All
9.	Origin Pro Software	Data analysis and scientific graphing	All

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Solid State Physics	Ashcroft N.W. and Mermin N.D.	Cengage Learning, 2011, ISBN: 978 8131500521
2.	A Quantum Approach to Solid state Physics	Taylor P.L. and Heinonen O.	Cambridge University Press, 2002, ISBN: 978-0521777827
3.	Principles of Solid state Physics	Chaikin P.M. and Lubensky T.C.	Cambridge University Press, 1995, ISBN: 978-0521794503
4.	Introduction to Solid State Physics	Kittel C.	Wiley, 8th Edition, 2004, ISBN: 978 0471415268
5.	Solid State Physics	Grosso G. and Parravicini G.P.	Academic Press, 2nd Edition, 2013, ISBN: 978-0123851543

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
6.	An Introduction to Soft Matter	Hamley I.W.	John Wiley & Sons, 2007, ISBN: 978 0470516966

b) Online Educational Resources (OER):

1) https://https://nptel.ac.in/courses/115/103/115103027/ - Solid State Physics, IIT Bombay
2) https://ocw.mit.edu/courses/physics/8-231-physics-of-solids-i-fall-2006/ - MIT Physics of Solids
3) https://www.doitpoms.ac.uk/ - DoITPoMS Materials Science Resources
4) https://materialsproject.org/ -Materials Project Database
5) https://www.youtube.com/playlist?list=PLUl4u3cNGP63HkEHvYaNJiO0UCUmY0Ts7 - MIT Solid State Chemistry

Q) Course Curriculum Developer

S. No.	Name	E-mail Address
1.	Prof. Hussain Jeevakhan	hjeevakhan@nitttrbpl.ac.in

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A)	**Course Title:** Physics of Semiconductor Devices	Deemed to be University under Distinct Category
B)	**Course Code:** MSCPST04/....	
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
MSCPST04.CO1	Analyze Band structures of different materials, carrier transport mechanisms and their effects.
MSCPST04.CO2	Design circuit with proper utilization of semiconductor p-n diodes and Schottky barrier diodes to achieve specific functionality.
MSCPST04.CO3	Design BJT-based circuits for specific application.
MSCPST04.CO4	Integrate MOSFETs into larger electronic systems and circuits effectively.
MSCPST04.CO5	Predict the behavior of different optoelectronic devices.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)			
	PO-1 Demonstrate the acquisition of procedural knowledge required for performing and accomplishing complex and specialised and professional tasks relating to teaching, research and development.	**PO-2** Demonstrate the acquisition of advanced cognitive and technical skills required for evaluating research findings and designing and conducting research in Semiconductor Science.	**PO-3** Apply advanced knowledge relating to research methods to carry out research and investigations to formulate evidence-based solutions to complex and unpredictable problems in semiconductor science and technology.	**PO-4** Communicate, in a well-structured manner, technical information and explanations, and the findings/results of the research studies undertaken in the field of semiconductor science and technology, by following basic research ethics
MSCPST04.CO1	3	1	3	1
MSCPST04.CO2	3	1	3	1
MSCPST04.CO3	3	1	3	1
MSCPST04.CO4	3	1	3	1
MSCPST04.CO5	3	1	3	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)	
MSCPST04	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 junctions	**CO2**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
	2.3 Computational Intelligence in Junction Analysis: • Machine learning algorithms for diode characterization and parameter extraction • AI models for predicting junction behaviour under extreme conditions	
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	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
	4.3 Knowledge integration from ancient Indian metallurgical practices in modern fabrication approaches	
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. *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.	**Unit-5.0 JFET, MESFET and Semiconductor Optoelectronics** 5.1 **JFET and MESFET:** • Introduction, JFET, MESFET structure and operation • Current-voltage characteristics • 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	**CO5**

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

i. Investigate how temperature affects the mobility and performance (conductivity, carrier concentration) of different semiconductor materials (e.g., Silicon, Gallium Arsenide).
ii. Investigate the correlation between ancient Indian metallic alloy preparation techniques and modern semiconductor doping strategies.
iii. 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
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:** 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 of	**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)
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 5.2 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 8.2. Apply Linear Regression and Multiple Linear Regression for predictive analysis. *LSO 8.3.* Evaluate the Linear and Multiple Linear Regression models with	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)
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

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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)						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)	
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

Q) Course Curriculum Developer

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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,	**CO1**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
	Repositories 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.
NEP04.CO3	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	-	-
NEP04.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)	
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.	**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)
TSO 1c. Explain the steps of Budgeting for the 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 Decisions for the given situation.	**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)
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

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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

S. No.	Course Codes	Course Titles	Page No.
1.	MSCPST05	Semiconductor Materials and their Applications	72
2.	MSCPST06	Semiconductor Processing and Fabrication	78
3.	MSCPST07	Nanoscience and Technology	85
4.	MSCPST08-09	Programme Elective Courses -1	-
5.	PD01	Project	107

A)	**Course Title:** Semiconductor Materials and their Applications	Deemed to be University under Distinct Category
B)	**Course Code: MSCPST05**	
C)	**Pre- requisite (s):**	

D) **Rationale:** The global semiconductor industry, valued at over $574 billion and experiencing unprecedented growth driven by AI, IoT, 5G communications, and electric vehicles, faces critical material challenges as traditional silicon technology approaches fundamental physical limits at sub-7nm nodes. This course addresses the urgent industry need for engineers skilled in next-generation materials, including compound semiconductors (GaN, SiC), 2D materials, advanced dielectrics, and piezoelectric sensing materials, while simultaneously meeting environmental compliance requirements.

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
MSCPST05.CO1	Analyse the role of materials in Semiconductor technology with environmental compliance
MSCPST05.CO2	Evaluate substrate materials, including direct and indirect bandgap semiconductors, for specific applications.
MSCPST05.CO3	Design metallic components for semiconductor metallization and interconnect systems.
MSCPST05.CO4	Select dielectric materials for semiconductor process technology applications
MSCPST05.CO5	Analyse piezoelectric materials and their integration in sensing device applications.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)			
	PO-1 Demonstrate the acquisition of procedural knowledge required for performing and accomplishing complex and specialised and professional tasks relating to teaching, research and development.	**PO-2** Demonstrate the acquisition of advanced cognitive and technical skills required for evaluating research findings and designing and conducting research in Semiconductor Science.	**PO-3** Apply advanced knowledge relating to research methods to carry out research and investigations to formulate evidence-based solutions to complex and unpredictable problems in semiconductor science and technology.	**PO-4** Communicate, in a well-structured manner, technical information and explanations, and the findings/results of the research studies undertaken in the field of semiconductor science and technology, by following basic research ethics
MSCPST05.CO1	1	-	1	1
MSCPST05.CO2	2	3	1	1
MSCPST05.CO3	2	2	1	1
MSCPST05.CO4	2	2	1	1
MSCPST05.CO5	2	3	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)	
MSCPST05	PCC	Semiconductor Materials and their Applications	30	15	-	45	90	03	30	50	40	-	-	-	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 the critical role of various materials in different semiconductor technologies. *TSO 1b.* Differentiate between key environmental regulations impacting semiconductor packaging, specifically RoHS and REACH	**Unit-1.0 Materials in Semiconductor Technology** 1.1 Role of materials in semiconductor packaging 1.2 Lattice planes and Miller indices 1.3 Environmental regulations- ROHS (Restriction of Hazardous Substances), REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals)	**CO1**
TSO 2a. Classify different types of substrate materials based on their electronic and physical properties *TSO 2b.* Classify different types of substrate materials based on their electronic and physical properties. *TSO 2c.* Apply characterisation techniques for evaluating substrate material quality and suitability.	**Unit 2.0 Substrates used in Semiconductor Technology** 2.1 Types of materials used as substrates in Semiconductor process technology 2.2 Direct and indirect bandgap semiconductor material – Si, Ge, GaAs, etc. 2.3 Characterisation of substrate materials 2.4 Applications of different substrate materials in semiconductor process technology	**CO2**
TSO 3a. Apply material selection criteria for choosing appropriate metals (Al, Au, Cu, Cr) for specific metallization applications. *TSO 3b.* Explain the fundamental mechanisms of interdiffusion in semiconductor metallurgy. *TSO 3c.* Classify different types of solder alloys	**Unit-3.0 Metals used in Semiconductor Technology** 3.1 Commonly used metals e.g. Al, Au, Cu, Cr, etc. for metallization in Semiconductor process Technology 3.2 Kirkendall Effect in Semiconductor Metallurgy 3.3 Solders: Metal alloys, different types of solder materials **3.4** Application of materials used for metallization in semiconductor processes	**CO4**
TSO 4a. Classify different types of dielectric materials used in semiconductor process technology. *TSO 4b.* Compare deposition techniques for dielectric materials and their impact on material properties. *TSO 4c.* Apply characterisation methods to evaluate dielectric material performance in device applications.	**Unit-4.0 Dielectric Materials** 4.1 Different types of dielectric materials used in semiconductor technology. 4.2 Deposition techniques of dielectric materials 4.3 Application of dielectric materials in Semiconductor process Technology 4.4 Characterisation of dielectric materials	**CO4**
TSO 5a. Classify piezoelectric materials (PZT, PLZT, $BaTiO_3$, $SrTiO_3$, BST) based on their structure and properties	**Unit -5.0: Materials for Sensing Devices** 5.1 Piezoelectric materials – PZT, PLZT, BaTiO3, SrTiO3, BST	**CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 5b. Evaluate deposition techniques for piezoelectric materials and their process compatibility. *TSO 5c.* Apply characterization methods for assessing piezoelectric material performance in sensing applications.	5.2 Deposition techniques of piezoelectric materials 5.3 Characterization of piezoelectric materials 5.4 Application of piezoelectric materials	

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

i. Investigate the impact of RoHS and REACH regulations on next-generation packaging material selection for 5G communication devices
ii. Develop a decision matrix for material substitution strategies to comply with evolving environmental regulations.
iii. Analyze the relationship between crystal orientation (Miller indices) and thermal expansion mismatch in semiconductor packaging
iv. Design optimal crystal orientations for minimizing thermal stress in heterogeneous material interfaces
v. Compare performance of traditional silver-filled epoxy vs. sintered silver nanoparticles for high-power LED 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):

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

- Compare different packaging materials (organic vs. ceramic substrates, epoxy molding compounds, etc.) and evaluate their impact on device performance and reliability
- Analyze the effectiveness of different Thermal interface materials (TIMs) in high-power semiconductor applications
- Compare different die attach materials (epoxy, solder, silver sintering) and analyze their impact on thermal and electrical performance

b. Seminar Topics:

- Metamaterials for Eelctronics
- 2D Materials in Semiconductor
- Properties of crystalline and amorphous Silicon
- Semiconductor quantum dots

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 Materials in Semiconductor Technology	08
CO2	Unit-2.0 Substrates used in Semiconductor Technology	10
CO3	Unit-3.0 Metals used in Semiconductor Technology	10
CO4	Unit-4.0 Dielectric Materials	12
CO5	Unit-5.0 Materials for Sensing Devices	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.	Properties of Advanced Semiconductor Materials: GaN, AlN, InN, BN, SiC, SiGe	M.E. Levinshtein, S.L. Rumyantsev, M.S. Shur	1st Ed., 2001,978-0471358275
2.	Introduction to Semiconductor Materials and Devices	M. S. Tyagi	Revised Ed., 2008 978-8126518678

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
3.	Semiconductor Materials	Lev I. Berger	1st Ed., 1996 978-0849389122

b) Online Educational Resources (OER):

1) https://www.coursera.org/learn/introduction-to-semiconductor-packaging
2) https://ocw.mit.edu/courses/3-091sc-introduction-to-solid-state-chemistry-fall-2010/
3) https://openstax.org/books/university-physics-volume-3
4) https://www.coursera.org/learn/materials-science

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A)	**Course Title:** Semiconductor Processing and Fabrication	Deemed to be University under Distinct Category
B)	**Course Code:** MSCPST06	
C)	**Pre- requisite (s):**	

D) **Rationale:** The fabrication of semiconductor 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. Semiconductor technology evolves new fabrication techniques integrated with AI/ML algorithms that 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. 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
MSCPST06.CO1	Analy Analyse the various processes and technologies involved in semiconductor fabrication
MSCPST06.CO2	Interpret the theoretical principles underlying semiconductor fabrication, including materials science, electronic properties, microfabrication techniques, and sustainable materials selection.
MSCPST06.CO3	Apply photolithography and etching techniques in semiconductor fabrication
MSCPST06.CO4	Suggest impurity types and doping concentration profiles using ML-based prediction models and optimisation algorithms
MSCPST06.CO5	Use metallization Techniques for semiconductor device fabrication.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)			
	PO-1 Demonstrate the acquisition of procedural knowledge required for performing and accomplishing complex and specialised and professional tasks relating to teaching, research and development.	**PO-2** Demonstrate the acquisition of advanced cognitive and technical skills required for evaluating research findings and designing and conducting research in Semiconductor Science.	**PO-3** Apply advanced knowledge relating to research methods to carry out research and investigations to formulate evidence-based solutions to complex and unpredictable problems in semiconductor science and technology.	**PO-4** Communicate, in a well-structured manner, technical information and explanations, and the findings/results of the research studies undertaken in the field of semiconductor science and technology, by following basic research ethics
MSCPST06.CO1	3	1	2	1
MSCPST06.CO2	3	1	2	1
MSCPST06.CO3	3	1	2	2
MSCPST06.CO4	3	1	2	1
MSCPST06.CO5	3	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)						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)	
MSCPST06	PCC	Semiconductor Processing and Fabrication	30	15	45	30	120	04	30	50	40	-	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. Summarize the Semiconductor fabrication process with suitable sketches. *TSO 1b.* Analyse various sustainable semiconductor materials for various applications. *TSO 1c.* Evaluate AI applications in smart fab environments	**Unit-1.0 Introduction to Semiconductor Fabrication:** 1.1 Overview of the semiconductor fabrication process. 1.2 Sustainable semiconductor materials, their properties, and use for Semiconductor device fabrication. 1.3 Introduction to AI/ML in semiconductor manufacturing	**CO1**
TSO 2a. Describe the crystal growth process used for semiconductor fabrication. *TSO 2b.* Explain the need for a Cleanroom in IC fabrication processes, specifically for wafer preparation. *TSO 2c.* Describe the wafer slicing procedure and its types in detail *TSO 2d.* Describe crystal growth processes and ML-based quality prediction	**Unit -2.0 Crystal Growth and Wafer Preparation** 2.1 Crystal structures and properties, Crystal growth techniques (e.g., Czochralski method) 2.2 Wafer Slicing and Polishing, Wafer grinding and lapping 2.3 Cleanroom design and maintenance, Cleanroom protocols and procedures, 2.4 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.* Compare various types of lithography procedures. *TSO 3d.* Describe photolithography principles and AI optimisation techniques *TSO 3e.* Design ML models for etch process prediction *TSO 3f.* Implement computer vision for pattern inspection	**Unit-3.0 Photolithography and etching** 3.1 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, 3.2 Lithography and Patterning: - Advanced lithography techniques (e.g., EUV lithography), 3.3 Patterning of features at nanoscale, Resolution enhancement techniques, Machine learning for lithography process optimization 3.4 AI-assisted mask design and layout optimization, Predictive models for etch rate and selectivity	**CO3**
TSO 4a. Describe the Ion implantation procedure in detail. *TSO 4b.* Differentiate between Ion implantation and the Doping procedure. *TSO 4c.* Describe the metallization procedure in detail	**Unit-4.0 Ion Implantation and Doping** 4.1 Ion Implantation and Doping: - Introduction to ion implantation, Doping processes for introducing impurities 4.2 Annealing techniques for activating dopants, Device Isolation and Interconnection: -	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 4d. Describe ion implantation with ML-based parameter optimization *TSO 4e.* Predict doping profiles using machine learning models *TSO 4f.* Implement AI for metallization process control *TSO 4g.* Differentiate traditional and AI-enhanced doping procedures	Techniques for isolating individual devices on a chip, 4.3 Interconnection schemes (e.g., metallization layers), Planarization processes (e.g., chemical mechanical polishing) 4.4 Machine learning for doping profile prediction, AI-optimized ion implantation parameters	
TSO 5a. Describe the principles and applications of PVD and CVD techniques for metallization in semiconductor device fabrication. *TSO 5b.* Explain the working mechanism of thermal evaporation and electron beam evaporation techniques in IC metallization *TSO 5c.* Compare sputtering techniques with other metallization methods in terms of efficiency and application	**Unit -5.0 Metallization Techniques** 5.1 PVD and CVD Techniques for Semiconductor Device Fabrications 5.2 Thermal Evaporation techniques 5.3 Electron Beam Evaporation Techniques 5.4 Sputtering Techniques	**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	1.	Standard Cleanroom Procedures	CO2
LSO 2.1 Prepare photolithography masks for the various types of device fabrications using AI assisted design tool. *LSO 2.2* Create photolithography masks using AI-assisted design tools.	2.	Photolithography mask preparation.	CO3
LSO 3.1 Use PVD Techniques for metallization in semiconductor devices	3.	PVD metallization	CO5
LSO 4.1 Develop computer vision systems for defect detetction	4.	Computer vision for QC	CO3
LSO 5.1. Use electron beam evaporation technique for semiconductor device fabrication	5.	Electron beam evaporation technique	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):

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

- 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. Seminar Topics:

- IC fabrication Technology
- PVD and CVD
- Battery Electrode Materials
- Semiconductor quantum dots

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 Semiconductor Fabrication	08
CO2	Unit-2.0 Crystal Growth and Wafer Preparation	10
CO3	Unit-3.0 Photolithography and etching	12
CO4	Unit-4.0 Ion Implantation and Doping	10
CO5	Unit -5.0 Metallization Techniques	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:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience /Practical Number
1.	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
2.	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
3.	PVD Setup	The Physical Vapor Deposition (PVD) setup for semiconductor fabrication features a high-vacuum chamber (10^{-6} to 10^{-8} Torr), supporting sputtering and thermal evaporation for depositing high-purity metals (e.g., Al, Cu) on wafers up to 6 inches. It includes a rotatable substrate holder (up to 500°C), DC/RF power supply (500 W–5 kW), mass flow controllers for gases, and a quartz crystal monitor for thickness control (±1 nm), with automated PLC-based controls and safety interlocks.	4
4.	Electron Beam Evaporation Setup	The Electron Beam Evaporation setup uses an ultra-high vacuum chamber (10^{-7} to 10^{-9} Torr), an electron gun (3–10 kV, 1–5 kW) with multiple crucibles, and a heated substrate stage (up to 600°C) for wafers up to 8 inches. It offers precise beam control, in-situ thickness monitoring (±0.1 nm), and automated software for high-purity film deposition, with safety features like radiation shielding.	5

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)

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 Development Team

S. No.	Name	E-mail Address
1.	Dr. Anjali Potnis	apotnis@nitttrbpl.ac.in
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3.	Ms. Shilpi Srivastav	Shilpi.nitj@gmail.com

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A)	**Course Title:** Nanoscience and Technology	Deemed to be University under Distinct Category
B)	**Course Code:** MSCPST07	
C)	**Pre- requisite (s):** Solid State Physics, Materials Science Fundamentals	

D) **Rationale:** Nanoscience and technology represent one of the most rapidly advancing frontiers in modern science and engineering. This course provides a comprehensive understanding of nanoscale phenomena, synthesis methods, characterization techniques, and applications of nanomaterials. It enables learners to understand quantum size effects, surface phenomena, and unique properties that emerge at the nanoscale. The knowledge gained is essential for advanced research in nanotechnology, materials engineering, and the development of next-generation devices for electronics, energy, medicine, and environmental 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
MSCPST07.CO1	Analyse various synthesis methods for nanoparticles for their size-dependent properties.
MSCPST07.CO2	Evaluate structural and electronic properties of carbon nanostructures, including fullerenes, nanotubes, and graphene.
MSCPST07.CO3	Apply quantum confinement concepts to analyse the properties of quantum wells, wires, and dots.
MSCPST07.CO4	Use advanced characterisation techniques for structural and property analysis of nanomaterials.
MSCPST07.CO5	Investigate the synthesis and properties of bulk nanostructured materials and their applications

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)			
	PO-1 Demonstrate the acquisition of procedural knowledge required for performing and accomplishing complex and specialised and professional tasks relating to teaching, research and development.	**PO-2** Demonstrate the acquisition of advanced cognitive and technical skills required for evaluating research findings and designing and conducting research in Semiconductor Science.	**PO-3** Apply advanced knowledge relating to research methods to carry out research and investigations to formulate evidence-based solutions to complex and unpredictable problems in semiconductor science and technology.	**PO-4** Communicate, in a well-structured manner, technical information and explanations, and the findings/results of the research studies undertaken in the field of semiconductor science and technology, by following basic research ethics
MSCPST07.CO1	3	3	2	1
MSCPST07.CO2	3	3	2	1
MSCPST07.CO3	3	3	2	1
MSCPST07.CO4	3	3	2	1
MSCPST07.CO5	3	3	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)	
MSCPST07	PCC	Nanoscience and Technology	30	15	-	45	90	03	30	50	40	-	-	-	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 various physical and chemical synthesis methods for nanoparticles *TSO 1b.* Analyse biological synthesis routes using microorganisms and plant extracts *TSO 1c.* Explain meta-nanoclusters and the magic number concept *TSO 1d.* Apply computational modelling to predict nanoparticle properties *TSO 1e.* Analyse bulk to nano transitions and size effects	**Unit-1.0 Nanoparticles: Synthesis and Properties** 1.1 Methods of Synthesis: RF Plasma Chemical Methods 1.2 Thermolysis and Pulsed Laser Methods 1.3 Biological Methods: Synthesis using micro-organisms 1.4 Synthesis using Plant Extract 1.5 Metal Nanoclusters and Magic Numbers 1.6 Modelling of Nanoparticles 1.7 Bulk to Nano Transitions	**CO1**
TSO 2a. Explain the nature and formation of carbon clusters *TSO 2b.* Analyse the structure and properties of C60fullerenes *TSO 2c.* Explain superconductivity in fullerenes *TSO 2d.* Evaluate synthesis methods and structure of carbon nanotubes *TSO 2e.* Analyse the electrical and mechanical properties of CNTs *TSO 2f.* Analyse various synthesis methods for graphene *TSO 2g.* Apply TEM for structural characterisation of graphene *TSO 2h.* Evaluate elementary applications of graphene	**Unit 2.0 Carbon Nanostructures** 2.1 Nature of Carbon Clusters 2.2 Discovery of C60 2.3 Structure of C60 and its Crystal 2.4 Superconductivity in C60 2.5 Carbon Nanotubes: Synthesis and Structure 2.6 Electrical and Mechanical Properties of CNTs 2.7 Discovery of Graphene 2.8 Synthesis Methods 2.9 Structural Characterisation through TEM 2.10 Elementary Concept of Applications	**CO2**
TSO 3a. Analyze preparation methods for quantum nanostructures *TSO 3b.* Explain the quantum size effects and confinement *TSO 3c.* Evaluate conduction electrons and dimensionality effects *TSO 3d.* Apply density of states concepts to quantum structures *TSO 3e.* Explain the elementary concepts of 2D materials.	**Unit-3.0 Quantum Wells, Wires and Dots** 3.1 Preparation of Quantum Nanostructures 3.2 Size Effects and Quantum Confinement 3.3 Conduction Electrons and Dimensionality 3.4 Properties Dependent on Density of States 3.5 Elementary idea of 2D materials	**CO4**
TSO 4a. Apply scanning probe microscopy techniques for nanoscale analysis *TSO 4b.* Utilise diffraction techniques for structural *TSO 4c.* Employ spectroscopic methods for property analysis *TSO 4d.* Apply magnetic measurement techniques to nanomaterials	**Unit -4.0 Analysis Techniques for Nanostructures/Particles** 4.1 Scanning Probe Microscopes (SPM) 4.2 Diffraction Techniques for Nanomaterials 4.3 Spectroscopic Techniques 4.4 Magnetic Measurement	**CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 5a. Analyze various synthesis methods for bulk nanostructured materials *TSO 5b.* Explain the solid disorder in nanostructures *TSO 5c.* Evaluate the mechanical properties of nanostructured materials *TSO 5d.* Analyze nanostructure multilayers and metal nanoclusters and composite glasses.	**Unit-5.0 Bulk Nanostructure Materials** 5.1 Solid Disorders Nanostructures 5.2 Mechanical Properties 5.3 Nanostructure Multilayers 5.4 Metal Nanocluster and Composite Glasses	**CO5**

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

i. Plasmonic Nanoparticles: Investigate synthesis and optical properties of gold and silver nanoparticles for SERS applications.
ii. 2D Material Heterostructures: Study the electronic properties of van der Waals heterostructures using computational methods.
iii. Perovskite Quantum Dots: Synthesize and characterise perovskite quantum dots for solar cell applications.
iv. Magnetic Nanoparticles: Develop magnetic nanoparticles for hyperthermia cancer treatment.
v. Catalytic Nanoparticles: Design and test nanoparticle catalysts for hydrogen production.
vi. Flexible Electronics: Develop graphene-based flexible electronic devices.
vii. Environmental Remediation: Study photocatalytic degradation of pollutants using semiconductor nanoparticles.
viii. Energy Storage: Investigate nanostructured materials for battery and super capacitor 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):

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

- Compare different synthesis methods for silver nanoparticles and their size control
- mechanisms.
- Explain quantum confinement effects in semiconductor quantum dots with mathematical derivation.
- Analyze the electronic band structure of single-walled carbon nanotubes.
- Discuss the principle and applications of scanning tunneling microscopy for nano material characterization.

- Evaluate mechanical properties enhancement in nanocomposites using rule of mixtures.

b. Seminar Topics:

- Nanoparticles in Drug Delivery
- Quantum Computing using Quantum Dots
- Graphene Applications in Electronics
- Nanotoxicology and Environmental Impact
- Nanomaterials for Solar Energy Conversion
- Smart Nanocoatings and Self-Healing Materials

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 Nanoparticles: Synthesis and Properties	10
CO2	Unit 2.0 Carbon Nanostructures	10
CO3	Unit 4.0 Quantum Wells, Wires and Dots	14
CO4	Unit 5.0 Analysis Techniques for Nanostructures/Particles	10
CO5	Unit 5.0 Bulk Nanostructure Materials	06
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.	Introduction to Nanotechnology	Poole C.P. and Owens F.J.	Wiley-Inter science, 2003, ISBN: 978-0471079354
2.	Quantum Dots	Jacak L., Hawrylak P., and Wojs A.	Springer, 1998, ISBN: 978-3540634010
3.	Handbook of Nanostructured Materials and Nanotechnology	Nalwa H.S. (editor)	Academic Press, 5 Volume Set, 1999, ISBN: 978-0125133609
4.	Nanotechnology: Principles and Practices	Kulkarni S.K.	Capital Publishing Company, 3rdEdition, 2015, ISBN: 978-8172733353
5.	Carbon Nanotubes	Fiorito S.	Nova Science Publishers, 2008, ISBN:978-1604561623
6.	Nanotechnology	Booker R. and Boysen E.	Wiley, 2005, ISBN: 978-0764575846
7.	Nanoscale Materials in Chemistry	Klabunde K. J. (editor)	Wiley-Inter science, 2nd Edition, 2001, ISBN: 978-0471383956
8.	Nanostructures and Nanomaterials	Cao G.	Imperial College Press, 2004, ISBN:978-1860943591

b) Online Educational Resources (OER):

1) https://nptel.ac.in/courses/115/103/115103056/ - Laser Technology, IIT Delhi
2) https://nptel.ac.in/courses/115/104/115104094/ - Nanoscience and Technology, IIT Bombay
3) https://ocw.mit.edu/courses/materials-science-and-engineering/3-054-cellular-solids-structure-properties-and-applications-spring-2015/
4) https://www.coursera.org/learn/nanotechnology - Introduction to Nanotechnology
5) https://www.edx.org/course/nanotechnology-and-nanosensors-part-1 - Nanotechnology andNanosensors
6) https://www.youtube.com/playlist?list=PLbMVogVj5nJTmKzaSlYQBdGCytgKyGRXp - Nanotechnology Lectures
7) https://www.nanowerk.com/ - Nanotechnology Portal and Information
8) https://www.nature.com/collections/nanotechnology - Nature Nanotechnology Articles
9) https://www.nano.gov/ - National Nanotechnology Initiative

Q) Course Curriculum Developer

S. No.	Name	E-mail Address
1.	Prof. Hussain Jeevakhan	hjeevakhan@nitttrbpl.ac.in

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A)	**Course Title:** Laser Physics and its Applications	Deemed to be University under Distinct Category
B)	**Course Code:** MSCPST08	
C)	**Pre- requisite (s):** Network Analysis, Semiconductor Physics Digital Electronics	

D) **Rationale:** Laser Physics and its Applications form the cornerstone of modern photonics and optical technology. This course provides a comprehensive understanding of laser principles, various laser systems, and their cutting-edge applications in science, technology, and industry. Students will explore the quantum mechanical foundations of laser operation, nonlinear optical processes, and emerging applications in atomic cooling, spectroscopy, and advanced manufacturing. The knowledge gained is essential for research in photonics, quantum optics, materials processing, and the development of next-generation optical devices.

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
MSCPST08.CO1	Analyze laser light characteristics, cavity modes, and resonator configurations for optimal laser design.
MSCPST08.CO2	Evaluate the principles and operational characteristics of different laser systems, including gas, solid-state, semiconductor, and speciality lasers.
MSCPST08.CO3	Apply nonlinear optical processes, including harmonic generation, stimulated, Scattering and fibre laser technologies.
MSCPST08.CO4	Investigate novel laser applications in atomic cooling, trapping, and quantum state manipulation.
MSCPST08.CO5	Implement laser-based solutions for spectroscopy, materials processing, and advanced optical systems.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)			
	PO-1 Demonstrate the acquisition of procedural knowledge required for performing and accomplishing complex and specialised and professional tasks relating to teaching, research and development.	**PO-2** Demonstrate the acquisition of advanced cognitive and technical skills required for evaluating research findings and designing and conducting research in Semiconductor Science.	**PO-3** Apply advanced knowledge relating to research methods to carry out research and investigations to formulate evidence-based solutions to complex and unpredictable problems in semiconductor science and technology.	**PO-4** Communicate, in a well-structured manner, technical information and explanations, and the findings/results of the research studies undertaken in the field of semiconductor science and technology, by following basic research ethics
MSCPST08.CO1	3	3	2	1
MSCPST08.CO2	3	3	2	1
MSCPST08.CO3	3	3	2	2
MSCPST08.CO4	3	3	2	2
MSCPST08.CO5	3	3	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)	
MSCPST08	PEC	Laser Physics and its Applications	30	15	45	30	120	04	30	50	40	-	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 laser light characteristics and coherence properties *TSO 1b.* Calculate cavity mode structures and resonator parameters *TSO 1c.* Analyze mode selection techniques and cavity configurations *TSO 1d.* Apply Q switching and mode-locking principles for pulse generation	**Unit-1.0 Laser Fundamentals and Cavity Design** 1.1 Laser light characteristics: coherence, monochromaticity, directionality 1.2 Longitudinal and transverse cavity modes 1.3 Mode selection techniques and cavity Q-factor 1.4 Q-switching and Mode locking mechanisms 1.5 Plane and Confocal cavity resonator. 1.6 Second Harmonic Generation principles	**CO1**
TSO 2a. Apply stimulated emission principles to laser operation *TSO 2b.* Analyze threshold conditions for laser oscillation. *TSO 2c.* Evaluate CO2 laser systems and gas laser dynamics *TSO 2d.* Investigate semiconductor laser structures and operation *TSO 2e.* Compare different solid-state and specialty laser systems	**Unit 2.0 Laser Systems and Operation Principles** 2.1 Basic principles of laser operation and population inversion 2.2 CO2 laser: principle, construction, and longitudinal/TE modes 2.3 Semiconductor lasers: threshold conditions and junction structures 2.4 Homostructure and Heterostructure p-n junction lasers 2.5 Nd-YAG lasers: operation and characteristics 2.6 Excimer lasers: principles and applications 2.7 Dye lasers: tunable laser operation 2.8 Free Electron Lasers: principles and unique properties	**CO2**
TSO 3a. Apply electromagnetic wave propagation in nonlinear media *TSO 3b.* Analyze self-focusing and phase matching conditions *TSO 3c.* Investigate fiber laser technologies and applications *TSO 3d.* Evaluate stimulated Raman scattering processes *TSO 3e.* Apply CARS spectroscopy techniques *TSO 3f.* Analyze saturation and multiphoton absorption phenomena	**Unit-3.0 Nonlinear Optical Processes** 3.1 Electromagnetic wave propagation in nonlinear media 3.2 Self-focusing phenomena and optical solutions 3.3 Phase matching conditions for frequency conversion 3.4 Fiber lasers: principles and applications 3.5 Stimulated Raman Scattering and Raman lasers 3.6 Coherent Anti Stokes Raman Spectroscopy (CARS) 3.7 Saturation spectroscopy and applications 3.8 Two-photon and multiphoton absorption processes	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 4a. Apply Doppler cooling principles to atomic manipulation *TSO 4b.* Analyze polarization gradient cooling mechanisms *TSO 4c.* Investigate various trapping techniques for atoms and ions *TSO 4d.* Evaluate evaporative cooling and Bose-Einstein condensation *TSO 4e.* Design optical manipulation systems for quantum applications	**Unit-4.0 Laser Cooling and Atomic Manipulation** 4.1 Principles of laser cooling and radiation pressure 4.2 Doppler cooling: theory and experimental implementation 4.3 Polarization gradient cooling and sub-Doppler temperatures 4.4 Ion traps: Paul and Penning trap configurations 4.5 Optical traps and optical tweezers 4.6 Magneto-Optical Traps (MOTs) and atom trapping 4.7 Evaporative cooling techniques 4.8 Bose-Einstein condensation in ultracold gases	**CO4**
TSO 5a. Design laser spectroscopy systems for precision measurements *TSO 5b.* Apply laser processing techniques for materials modification *TSO 5c.* Evaluate laser applications in medical and industrial fields *TSO 5d.* Investigate emerging quantum technologies using	**Unit -5.0: Advanced Applications and Emerging Technologies** 5.1 High-resolution laser spectroscopy and frequency combs 5.2 Laser materials processing: cutting, welding, and surface modification 5.3 Medical applications: laser surgery, therapy, and diagnostics 5.4 Quantum information processing with laser systems 5.5 Laser interferometry and gravitational wave detection 5.6 LIBS, Lidar and remote sensing applications 5.7 Laser safety protocols and standards 5.8 Future trends in laser technology and photonics	**CO5**

J) Suggested Laboratory Experiences:

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
LSO 1.1 Measure laser beam characteristics and spatial profiles *LSO 1.2* Analyze beam divergence and mode structure	1.	Laser Beam Characterization and Mode Analysis	CO1

Lab Session Outcomes (LSOs)		S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
LSO 2.1	Investigate cavity stability and resonance condition	2.	Laser Cavity Mode Analysis and Resonator Design	CO1
LSO 3.1	Measure the wave length of HeNe laser	3.	HeNe Laser Characterization	CO2
LSO 4.1 *LSO 4.2*	Investigate semiconductor laser properties vs. temperature and current Measure laser threshold current and efficiency	4.	Semiconductor Laser Characterization	CO2
LSO 5.1	Demonstrate second harmonic generation in nonlinear crystals	5.	Second Harmonic Generation and Nonlinear Optics	CO3
LSO 6.1. *LSO 6.2.*	Demonstrate laser cooling principles using simulation Calculate cooling rates and temperature limits	6.	Laser Cooling Simulation and Analysis	CO4
LSO 7.1. *LSO 7.2.*	Simulate of optical trap for microparticle manipulation Measure trapping forces and particle dynamics	7.	Optical Trapping and Atomic Manipulation	CO5

K) Suggested Research Based Problems

i. Investigate mode-locked fiber laser dynamics and pulse compression techniques using computational modeling.
ii. Analyze quantum cascade laser design for mid-infrared applications and optimize layer structures.
iii. Develop laser cooling schemes for novel atomic species and calculate achievable temperatures.
iv. Design photonic crystal laser cavities for enhanced light-matter interaction and improved efficiency.
v. Investigate nonlinear optical processes in metamaterials for frequency conversion applications.
vi. Analyze laser-plasma interactions for advanced materials processing and surface nanostructuring.
vii. Design quantum dot lasers for telecommunications applications with optimized emission wavelengths.
viii. Investigate laser-based quantum state preparation and manipulation for quantum computing 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):

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

b. Seminar Topics:

- Internet of Things (IoT) and Smart Sensor Networks
- Quantum Cascade Lasers and Mid-Infrared Applications
- Femtosecond Laser Technology and Ultrafast Phenomena
- Laser-based Quantum Computing and Information Processing
- Advanced Laser Cooling Techniques and Ultracold Physics
- Photonic Integrated Circuits and On-chip Lasers
- High-Power Fiber Lasers for Industrial Applications

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 Laser Fundamentals and Cavity Design	10
CO2	Unit 2.0 Laser Systems and Operation Principles	14
CO3	Unit 3.0 Nonlinear Optical Processes	12
CO4	Unit 4.0 Laser Cooling and Atomic Manipulation	08
CO5	Unit 5.0 Advanced Applications and Emerging Technologies 14	06
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:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience /Practical Number
1.	Computer system	Processor Intel Core i7, 8 GB RAM, 20 GB free disk space, GPU support	All
2.	HeNe Laser System	Stabilized HeNe laser, 632.8 nm, 1-5 mW output, beam profiling accessories	1, 3

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience /Practical Number
3.	Semiconductor Laser Diode	Tunable current source, temperature controller, 650-850 nm range	4
4.	Nonlinear Crystal (BBO/KDP)	Phase-matched crystals for SHG, AR coated, rotation mounts	5
5.	Optical Spectrum Analyzer	400-1700 nm range, 0.1 nm resolution, fiber coupled	6,7
6.	Power Meter and Detectors	Thermal and photodiode detectors, µW to W range	All
7.	Optical Components	Mirrors, lenses, beam splitters, polarizers, mounts	All
8.	Fiber Laser Components	Single-mode fibers, WDM couplers, fiber gratings	6
9.	MATLAB/Python Software	Numerical computation, data analysis, simulation	All
10.	COMSOL Multiphysics	Laser cavity modeling and thermal analysis	All

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Laser Spectroscopy and Instrumentation	W. Demtröder	Springer, 4th Edition, 2008, ISBN: 978 3540734154
2.	Principles of Lasers	O. Svelto	Springer, 5th Edition, 2010, ISBN: 978 1441913012
3.	Laser Cooling and Trapping	P.N. Ghosh	Springer, 1999, ISBN: 978-1563969065
4.	Frontiers in Atomic, Molecular and Optical Physics	S.P. Sengupta	World Scientific, 2005, ISBN: 978 9812561671
5.	Lasers - Theory and Applications	K. Thyagrajan and A.K. Ghatak	Springer, 2010, ISBN: 978-1441913210
6.	Introduction to Laser Physics	K. Shimoda	Springer, 1986, ISBN: 978-3540161387
7.	Nonlinear Optics	R.W. Boyd	Academic Press, 3rd Edition, 2008, ISBN: 978-0123694704
8.	Laser Physics and Applications	H. Weber and R. Poprawe	Springer, 2004, ISBN: 978-3540432159

b) Online Educational Resources (OER):

1) https://nptel.ac.in/courses/115/103/115103056/ - Laser Technology, IIT Delhi
2) https://ocw.mit.edu/courses/nuclear-engineering/22-51-quantum-theory-of-radiation
3) interactions-fall-2012/ - MIT Quantum Theory of Radiation
4) https://www.doitpoms.ac.uk/tlplib/lasers/index.php - DoITPoMS Laser Resources
5) https://www.youtube.com/playlist?list=PLUl4u3cNGP61-9PEhRognw5vryrSEVLPr - MIT Atomic
6) and Optical Physics
7) https://www.coursera.org/learn/laser-physics - Laser Physics Coursera Course
8) https://www.rp-photonics.com/encyclopedia.html - RP Photonics Encyclopedia

Q) Course Curriculum Developer

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A)	**Course Title:** Electronic Circuits and Systems	Deemed to be University under Distinct Category
B)	**Course Code:** MSCPST09	
C)	**Pre- requisite (s):** Network Analysis, Semiconductor Physics Digital Electronics	

D) **Rationale:** Classical Electronic Circuits and Systems form the foundation of modern electronics engineering and technology. This course provides a comprehensive understanding of analog and digital circuit design, signal processing systems, and microelectronic applications. Students will explore circuit analysis techniques, amplifier design, power electronics, communication systems, and embedded microprocessor systems. The knowledge gained is essential for careers in electronics design, telecommunications, automation, and emerging technologies like IoT, robotics, and artificial intelligence 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
MSCPST09.CO1	Analyze fundamental electronic circuits, including diodes, transistor amplifiers, and signal conditioning circuits
MSCPST09.CO2	Evaluate operational amplifier circuits, active filters, oscillators, and power electronic systems for practical applications.
MSCPST09.CO3	Apply digital logic principles to design combinational and sequential circuits, counters, and data conversion systems.
MSCPST09.CO4	Investigate communication systems, transmission methods, and instrumentation systems for real-world applications.
MSCPST09.CO5	Implement microelectronic systems including microprocessor-based circuits, control systems, and emerging technologies.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)			
	PO-1 Demonstrate the acquisition of procedural knowledge required for performing and accomplishing complex and specialised and professional tasks relating to teaching, research and development.	**PO-2** Demonstrate the acquisition of advanced cognitive and technical skills required for evaluating research findings and designing and conducting research in Semiconductor Science.	**PO-3** Apply advanced knowledge relating to research methods to carry out research and investigations to formulate evidence-based solutions to complex and unpredictable problems in semiconductor science and technology.	**PO-4** Communicate, in a well-structured manner, technical information and explanations, and the findings/results of the research studies undertaken in the field of semiconductor science and technology, by following basic research ethics
MSCPST09.CO1	3	3	2	1
MSCPST09.CO2	3	3	2	2
MSCPST09.CO3	3	3	2	1
MSCPST09.CO4	3	3	3	2
MSCPST09.CO5	3	3	3	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)	
MSCPST09	PEC	Electronics Circuits and Systems	30	15	45	30	120	04	30	50	40	-	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. Analyze diode circuits and switching applications *TSO 1b.* Design transistor switching circuits for practical applications *TSO 1c.* Apply potential dividers and capacitive circuits *TSO 1d.* Evaluate inductor behavior and magnetic field effects *TSO 1e.* Design basic amplifier circuits using MOSFET, BJT, and JFE	**Unit-1.0 Fundamental Electronic Circuits** 1.1 Diode characteristics and applications 1.2 Transistor switches: lamp control, alarms, heater switches 1.3 Overheating alerts and Schmitt trigger circuits 1.4 Logical control using transistors 1.5 Potential dividers and signal conditioning 1.6 Capacitor fundamentals and applications 1.7 Using capacitors in timing and filtering circuits 1.8 Electric and magnetic fields in circuits 1.9 Inductors and inductive circuits 1.10 Basic amplifier configurations: common-source, common-drain	**CO1**
TSO 2a. Design operational amplifier circuits for signal processing *TSO 2b.* Apply op-amps in mathematical operations and signal conditioning *TSO 2c.* Design active filters for frequency selective applications *TSO 2d.* Analyze oscillator circuits and waveform generation *TSO 2e.* Evaluate power amplifiers and power electronic devices *TSO 2f.* Design power supply circuits with regulation	**Unit -2.0 Operational Amplifiers and Power Electronics** 2.1 Operational amplifier fundamentals and configurations 2.2 Voltage comparators and inverting amplifiers 2.3 Op-amp applications: adders, difference amplifiers 2.4 Integrators and differentiators 2.5 Schmitt triggers: inverting and non-inverting 2.6 Waveform generators: ramp and square-wave 2.7 Active filters: low-pass, high-pass, band-pass 2.8 Oscillators: phase shift, Colpitts, Wien bridge 2.9 Power amplifiers and efficiency considerations 2.10 Thyristors and triacs for power control 2.11 Power supplies: rectification, filtering, and regulation.	**CO2**
TSO 3a. Apply Boolean algebra and logic gate operations *TSO 3b.* Design combinational logic circuits *TSO 3c.* Analyze sequential logic and state machines *TSO 3d.* Design counters and shift registers *TSO 3e.* Evaluate display devices and interfacing Apply data conversion techniques	**Unit-3.0 Digital Logic and Sequential System** 3.1 Logic gates and Boolean operations 3.2 Combinational logic design and optimization 3.3 Sequential logic: flip-flops and latches 3.4 Counters: synchronous and asynchronous 3.5 Shift registers and parallel-to-serial conversion	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
	3.6 Display devices: 7-segment, LCD, LED matrices 3.7 Analog-to-Digital Converters (ADC) 3.8 Digital-to Analog Converters (DAC) 3.9 Multiplexers and demultiplexers **3.10** Integrated circuit families and interfacing	
TSO 4a. Analyze audio and video signal processing systems *TSO 4b.* Evaluate noise sources and mitigation techniques *TSO 4c.* Design telecommunication system components *TSO 4d.* Apply different transmission methods and protocols *TSO 4e.* Investigate instrumentation and measurement systems *TSO 4f.* Design electronic control systems	**Unit-4.0 Communication and Control Systems** 4.1 Analog and digital audio systems 4.2 Video signal processing and display systems 4.3 Noise analysis and signal-to-noise ratio 4.4 Telecommunications principles and modulation 4.5 Cable transmission: coaxial, twisted pair, fiber optic 4.6 Optical transmission systems and components 4.7 Radio transmission: AM, FM, digital modulation 4.8 Instrumentation systems and transducer 4.9 Electronic control systems and feedback 4.10 Process control: proportional, integral, derivative (PID) 4.11 System fault diagnosis and troubleshooting	**CO4**
TSO 5a. Design microprocessor input/output interfaces *TSO 5b.* Apply programming techniques for embedded systems *TSO 5c.* Implement interrupt handling and memory management *TSO 5d.* Design robotic control systems *TSO 5e.* Investigate neural networks and AI applications *TSO 5f.* Evaluate emerging microelectronic technologies	**Unit-5.0 Microelectronic Systems and Emerging Technologies** 5.1 Microprocessor architecture and input/output systems 5.2 Data processing and arithmetic operations 5.3 Programming fundamentals and flowcharts 5.4 Interrupt handling and real-time systems 5.5 Direct and indirect addressing modes 5.6 Stack operations and subroutine calls 5.7 Assembly and high-level programming languages 5.8 Robotic systems and motion control 5.9 Neural networks and pattern recognition 5.10 Embedded systems and IoT applications 5.11 Green electronics and sustainable design	**CO5**

J) Suggested Laboratory Experiences:

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
LSO 1.1 Analyze diode characteristics and rectifier circuits *LSO 1.2* Design and test switching circuits.	1.	Diode Characteristics and Switching Applications	CO1
LSO 2.1 Design transistor amplifiers with different configuration *LSO 2.2* Measure gain, input/output impedance and frequency response	2.	Transistor Amplifiers: Common-Emitter and Common-Collector	CO1
LSO 3.1 Design and test operational amplifier circuits *LSO 3.2* Implement mathematical operations using op-amps	3.	Operational Amplifier Applications and Signal Processing	CO2
LSO 4.1 Design active filters for specific frequency responses *LSO 4.2* Analyze filter characteristics and performance	4.	Active Filter Design and Frequency Response Analysis	CO2
LSO 5.1 Design and test oscillator circuits *LSO 5.2* Measure frequency stability and waveform quality	5.	Oscillator Circuits and Waveform Generation	CO2
LSO 6.1 Design power supply circuits with regulation *LSO 6.2* Test load regulation and ripple characteristic.	6.	Power Supply Design: Rectification and Regulation	CO3
LSO 7.1. Design combinational logic circuits *LSO 7.2.* Implement Boolean functions using logic gates.	7.	Digital Logic Design and Boolean Implementation	CO3
LSO 8.1. Design and test counter circuits *LSO 8.2.* Implement shift registers and data manipulation	8.	Sequential Logic: Counters and Shift Registers	CO3
LSO 9.1. Interface ADC/DAC with microcontroller systems *LSO 9.2.* Test data conversion accuracy and resolution	9.	Data Conversion Systems: ADC and DAC Implementation	CO3
LSO 10.1. Design audio amplifier and signal processing circuits *LSO 10.2.* Measure frequency response and distortion	10.	Audio Systems and Signal Processing	CO4
LSO 11.1. Program microcontroller for embedded applications *LSO 11.2.* Implement interrupt handling and I/O control	11.	Microcontroller Programming and Embedded Systems	CO5

K) Suggested Research Based Problems

i. Design and optimize a low-power IoT sensor node with wireless communication capabilities.
ii. Investigate advanced power management techniques for renewable energy harvesting systems.
iii. Develop adaptive filter algorithms for noise cancellation in communication systems.
iv. Design high-frequency RF amplifiers for 5G communication applications.
v. Investigate memristor-based neural network implementations for edge computing.

vi. Develop fault-tolerant control systems for autonomous vehicle applications.
vii. Design energy-efficient digital signal processing algorithms for wearable devices.
viii. Investigate quantum-dot based electronic devices for next-generation computing

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:

- Internet of Things (IoT) and Smart Sensor Networks
- Power Electronics for Electric Vehicles and Renewable Energy
- 5G Communication Systems and RF Circuit Design
- Artificial Intelligence Hardware and Neuromorphic Computing
- Quantum Electronics and Quantum Computing Circuits
- Biomedical Electronics and Implantable Device Design
- Green Electronics and Sustainable Circuit Design

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 Fundamental Electronic Circuits	08
CO2	Unit -2.0 Operational Amplifiers and Power Electronics	12
CO3	Unit -3.0 Digital Logic and Sequential System	10
CO4	Unit -4.0 Communication and Control Systems	12
CO5	Unit-5.0 Microelectronic Systems and Emerging Technologies	08
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:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience /Practical Number
1.	Computer system	Processor Intel Core i5, 8 GB RAM, 15 GB free disk space	All
2.	Digital Oscilloscope	4-channel, 100 MHz bandwidth, 1 GSa/s sampling rate	All
3.	Function Generator	Multi-waveform, 20 MHz, arbitrary waveform capability	All
4.	DC Power Supply	Dual output, ±30V, 3A per channel, current limiting	All
5.	Digital Multimeter	6.5 digit, AC/DC voltage/current, resistance, frequency	All
6.	Component Tester	Numerical computation and data analysis	1,2
7.	Breadboard and Components	Transistor, diode, capacitor, inductor testing	All
8.	Microcontroller Development Board	Solderless breadboards, resistors, capacitors, ICs	11
9.	Logic Analyze	ARM Cortex-M based, USB programming, GPIO, ADC, PWM	7,8,9
10.	Spectrum Analyzer	16-channel, 200 MHz, protocol decoding capability	10,11
11.	Signal Generator	RF signal generation, modulation capabilities	11
12.	SPICE Simulation Software	LTSpice, PSpice, or equivalent circuit simulator	All
13.	MATLAB/Simulink	Signal processing, control system design	All
14.	LabVIEW Software	Virtual instrumentation and data acquisition	10,11
15.	Robotic Kit	Servo motors, sensors, microcontroller platform	11
16.	FPGA Development Board	Servo motors, sensors, microcontroller platform	11

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Electronic Circuits and Systems	Owen Bishop	Newnes, 4th Edition, 2011, ISBN: 978 0080966342
2.	Microelectronic Circuits	A.S. Sedra and K.C. Smith	Oxford University Press, 7th Edition, 2014, ISBN: 978-0199339136
3.	Electronic Devices and Circuit Theory	R.L. Boylestad and L. Nashelsky	Pearson, 11th Edition, 2012, ISBN: 978 0132622264
4.	Operational Amplifiers and Linear ICs	R.A. Gayakwad	Pearson, 4th Edition, 2000, ISBN: 978 0132808682
5.	Operational Amplifiers and Linear ICs	J.F. Wakerly	Pearson, 4th Edition, 2005, ISBN: 978 0131863897
6.	Communication Systems	S. Haykin	Wiley, 5th Edition, 2009, ISBN: 978 0471697909
7.	The Art of Electronics	P. Horowitz and W. Hill	Cambridge University Press, 3rd Edition, 2015, ISBN: 978-0521809269
8.	Power Electronics: Converters, Applications, and Design	N. Mohan, T.M. Undeland, W.P. Robbins	Wiley, 3rd Edition, 2002, ISBN: 978 0471226932

b) Online Educational Resources (OER):

1) https://nptel.ac.in/courses/117/105/117105084/ - Electronic Circuits, IIT Kharagpur
2) https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and electronics-spring-2007/ - MIT Circuits and Electronics
3) https://www.allaboutcircuits.com/ - All About Circuits Online Textbook
4) https://www.electronics-tutorials.ws/ - Electronics Tutorials and Reference
5) https://www.youtube.com/playlist?list=PLBlnK6fEyqRiw-GZRqfnlVIBz9dxrqHJS – NPTEL Electronics Lectures
6) https://www.coursera.org/learn/electronics - Introduction to Electronics Coursera Course
7) https://www.edx.org/course/circuits-and-electronics - MIT Circuits and Electronics on edX

Q) Course Curriculum Developer

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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

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	Project shows some originality. Modifies or improves existing ideas or solutions in a meaningful way.	Project has limited newness. Mostly based on existing ideas with minor adjustments. Lacks	Project lacks originality. Direct replication of existing work with no new contribution.

S. No.	Criterion	Very Good (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
		significant different from existing work.	Offers partial innovation.	significant innovation.	
2.4	**Resourcefulness**	Demonstrates exceptional initiativeness and creativity in utilizing/arranging resources effectively.	Shows good use of resources and tools. Demonstrate moderate initiativeness and creativity in utilizing/ arranging resources.	Makes basic use of resources with limited initiative. Relies heavily on guidance.	Shows poor ability of utilizing/arranging resources.
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	Language is generally clear and appropriate. Style is mostly formal and consistent. The	Language is understandable, but is informal. Style occasionally deviates from the	Language is unclear, informal, or inappropriate for a technical report. Style is inconsistent

S. No.	Criterion	Very Good (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
		formal, consistent, and well-suited, hence enhancing the overall quality of the report.	quality of the report is acceptable.	formal standards. The quality of the report is moderate	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.
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	Slides are well-structured. Content is mostly relevant and supports the spoken presentation. Visuals are used appropriately. Minor	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

S. No.	Criterion	Very Good (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
		effectively. Excellent use of visuals (e.g., graphs, images, icons). Fonts, size, colours, and layout enhance readability.	issues in font size, colour, and layout.		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

S. No.	Name	E-mail Address
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Course Curriculum Detailing- Online Spell -1

S. No.	Course Codes	Course Titles	Page No.
1.	PC01	Research Methodology	115
2.	PC02	Curriculum & Assessment	121
3.	NEP06	Indian Knowledge System (IKS)	128

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**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 5a. Illustrate the Structure of a Good Research Proposal *TSO 5b.* Write good research proposal *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	**Unit -5.0 Research Proposal** 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	**CO5**

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

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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
3.	Principles of Curriculum Construction	Balasara, M	Kanishka; First Edition (1 January 2017), ISBN-10: 8173916217 ISBN-13: 978-8173916212

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
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.LOKANA DHA 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

S. No.	Course Codes	Course Titles	Page No.
1.	PC03	MOOC Creation	136
2.	PC04	Learner Centric Instructional Methods	142
3.	NEP07	Intellectual Property Rights (IPR)	148

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

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

Q) Course Curriculum Development Team

S. No.	Name	E-mail Address
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2.	Prof. Chanchal Mehra	cmehra@nitttrbpl.ac.in

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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 Tec hnology.	**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 kno wledge 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)						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)	
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)