Curriculum

M.Sc. Biopharmaceutical Science

July, 2025

School of Sciences

Department of
Applied Science Education

Deemed to be University under Distinct Category

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

(Deemed to be University under Distinct Category)

Ministry of Education, Government of India

Shamla Hills, Bhopal – 462 002

Madhya Pradesh, India

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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.

20/8/25

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

2. Introduction:

Biopharmaceuticals are medicinal products derived from biological sources, such as cells, tissues, genes, antibodies, or vaccines. They are used to prevent, diagnose, and treat various diseases, such as cancer, diabetes, autoimmune disorders, and infectious diseases. Biopharmaceuticals are also one of the fastest-growing segments of the global pharmaceutical industry, with an estimated market value of over $300 billion by 2025.

The development and production of biopharmaceuticals require a multidisciplinary approach that integrates knowledge and skills from various fields, such as biology, chemistry, engineering, pharmacology, immunology, and regulatory affairs. Therefore, there is a high demand for qualified professionals who can contribute to the innovation and advancement of biopharmaceutical sciences.

This M. Sc in Biopharmaceutical Sciences 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 biopharmaceutical sciences. The program also aims to develop students' research and analytical skills and their professional and ethical competencies to prepare them for careers in the biopharmaceutical industry, academia, or government agencies.

The programme consists of 4 offline and 2 online spells, totalling 82 credits. There is a provision for students to exit the course after completing a second offline spell, followed by one additional exit course to enhance his/her skills in Biopharmaceutical science. The curriculum includes different courses to develop professional-specific skills in the technology domain and pedagogy as well 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:

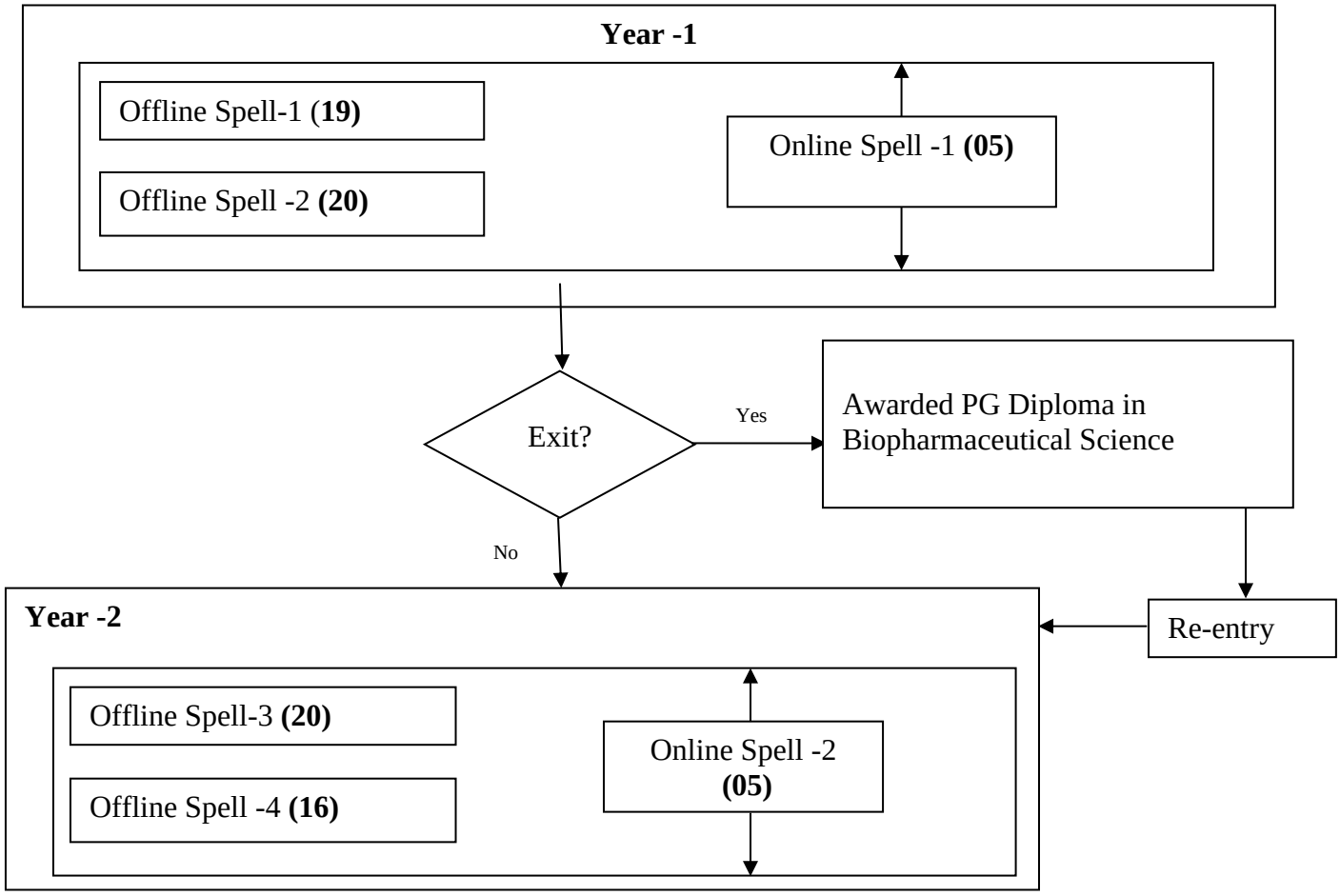
The curriculum is designed after identifying the current job title of the industry where pass-out students will be absorbed. Later, different job skills required for the professionals are identified. These job skills are further mapped with the courses to be offered. Course outcomes for all the courses 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 programme is 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 the 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: The department commits itself to accomplish the following missions:

- 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 applied sciences, engineering education, and training.
- Enhance international outreach through various linkages with other organizations and agencies.

7. Programme Educational Objectives (PEOs):

PEO1: Have a successful technical/professional career in educational institutions.

PEO2: Have a successful technical/professional career in the Pharma industry/ research & other organisations.

PEO3: Pursue higher studies and continue their professional development.

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

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

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

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

PO-2 Demonstrate acquiring advanced cognitive and technical skills required for evaluating research findings and designing and conducting research in Biopharmaceutical Science.

PO-3 Apply advanced knowledge of research methods to conduct research and investigations to formulate evidence-based solutions to complex and unpredictable problems in Biopharmaceutical Science.

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 Biopharmaceutical Science, by following basic research ethics.

9. Employment Potential:

Sample Employment and self-employment avenues are mentioned below-

9.1. Employment Avenues:

- Research Scholar in drug discovery and development
- Research Associate,
- Technical Officer
- Process Development Scientist for manufacturing optimisation
- Research Officer
- Bio-Analytical Scientist for drug testing and characterisation
- Bioanalytical Scientist for pharmacokinetic studies
- Production Manager
- AI/ML Specialist for drug development applications
- Project Assistant
- Lecturer/Assistant Professor in universities and colleges
- Bioinformatics Specialist for drug discovery
- Consultant for pharmaceutical business development
- Business Development Manager in life sciences companies
- Quality Control Analyst
- Quality Assurance Manager

9.2. Self-Employment Avenues:

- Founder of biotech startup companies
- Consultant for pharmaceutical business development
- Freelance regulatory consultant
- Technical Consultant for manufacturing setups
- Patent Analyst for intellectual property firms

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

1.	**Title of Programme**	:	M.Sc. Programme in Biopharmaceutical Science
2.	**Board of Studies**	:	Biopharmaceutical Science
3.	**Duration of Programme**	:	Two Years
4.	**Entry Qualification**	:	B.Sc. with a Major in Chemistry, B. Sc Biology/ Microbiology/ Biochemistry/ Biotech/B. Pharma/B. Tech (Chemical, Biotech)
5.	**Total Marks**	:	3660
6.	**Total Credits**	:	82
7.	**Total Number of Courses**	:	23

Summary of Credits and Marks

S. No	Spell	Credits	Total Marks
Year -1			
1.	Offline Spell - 1	17	730
2.	Offline Spell –2	18	700
3.	Online Spell – 1 (PD& NEP)	05	250
Total		**40**	**1680**
Year-2			
4.	Offline Spell - 3	21	930
5.	Offline Spell - 4	16	800
6.	Online Spell – 2 (PD & NEP)	05	250
Total		**42**	**1980**
Grand Total		**82**	**3660**

Category wise Courses

S. No.	Course Category	Abbreviations	Number of Courses	Total Credits
1.	Programme Core Courses	PCC	07	24
2.	Programme Elective Courses	PEC	04	12
3.	Stream Specific Diversified Courses (if applicable)	SSC	-	-
4.	Open Elective Courses (Common Basket)	OEC	02	06
5.	Project, Dissertation	PD	03	29
6.	Pedagogy Courses	PC	04	08
7.	NEP Courses	NEP	03	03
Total			**23**	**82**

M.Sc. (Biopharmaceutical Science)- MSCBS

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)		
MSCBS01	PCC	**Biochemistry**	30	15	-	45	90	03	30	50	40	-	-	-		120
MSCBS02	PCC	**Biostatistics**	30	15	-	45	90	03	30	50	40	-	-	-		120
MSCBS03	PCC	**Human Physiology**	30	15	-	45	90	03	30	50	40	-	-	-		120
MSCBS04	PCC	**Biopharmaceuticals**	45	15	-	30	90	03	30	50	40	-	-	-		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 Courses**	15	-	-	15	30	01	25	-	25	-	-	-		50
Total			**180**	**75**	**45**	**210**	**510**	**17**	**175**	**270**	**205**	**-**	**20**	**30**		**700**

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)	
MSCBS05	PCC	**Cell and Microbiology**	30	15	45	30	120	04	30	50	40	-	20	30	170
MSCBS06	PEC	**Programme Elective Course-1**	45	15	-	30	90	03	30	50	40	-	-	-	120
MSCBS07-08	PEC	**Programme Elective Course-2**	45	15	-	30	90	03	30	50	40	-	-	-	120
-	OEC	**Open Elective Course-1**	30	15	-	45	90	03	30	50	40	-	-	-	120
PD01	PD	**Project**	-	-	45	105	150	05	-	-	200	-	-	-	200
Total			**150**	**60**	**90**	**240**	**540**	**18**	**120**	**200**	**360**	**-**	**20**	**30**	**730**

Legends:

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

Programme Elective Course -1: Bioinformatics (MSCBS06)
Programme Elective -2: Molecular Modelling and Drug Design (MSCBS07)/ Formulation Strategies and Pharmacokinetics (MSCBS08)

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

Online Spell –1

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

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

Legends:

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

Year – 2

Offline Spell – 3

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
MSCBS09	PCC	**Bioinstrumentation**	45	15	45	15	120	04	30	50	40	-	20	30	170
MSCBS10-11	PEC	**Programme Elective Course -3**	45	15	-	30	90	03	30	50	40	-	-	-	120
MSCBS12-13	PEC	**Programme Elective Course -4**	45	15	-	30	90	03	30	50	40	-	-	-	120
MSCBS14-15	OEC	**Open Elective Course -2**	45	15	-	30	90	03	30	50	40	-	-	-	120
PD02	PD	**Dissertation Part -I**	-	-	90	150	240	08	-	-	300	100	-	-	400
Total			**180**	**60**	**135**	**255**	**630**	**21**	**120**	**200**	**460**	**100**	**20**	**30**	**930**

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 -3: Recombinant DNA Technology (MSCBS10)/ Biopharmaceutical Marketing and Management (MSCBS11)
Programme Elective -4: Vaccine and Immunotherapeutics (MSCBS12)/ AI, ML Computational Biopharmaceuticals and OMICS (MSCBS13)

Open Elective Course -2: Philosophy of Science and Research Ethics (MSCBS14)/ Value Creation and Entrepreneurship Development (MSCBS15)
Note: 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)						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
PC04	PC	**Learner Centric Instructional Methods**	30	-	-	30	60	02	30	50	20	-	-	-	100
NEP07	NEP	**Intellectual Property Rights (IPR)**	15	-	-	15	30	01	25	-	25	-	-	-	50
Total			**75**	**-**	**-**	**75**	**150**	**05**	**75**	**80**	**95**	**-**	**-**	**-**	**250**

Legends:

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

Course Curriculum Detailing- Offline Spell -1

A)	**Course Title:** Biochemistry	Deemed to be University under Distinct Category
B)	**Course Code:** MSCBS01	
C)	**Pre-requisite (s):**	

D) **Rationale:** This foundational course provides a comprehensive understanding of biochemical principles essential for biopharmaceutical sciences. Students will explore the structure-function relationships of biomolecules, metabolic pathways, and energetics that underpin drug action, biotechnology processes, and pharmaceutical development. The course integrates molecular biology concepts with practical applications in drug discovery, biomanufacturing, and therapeutic interventions, preparing students to understand how biochemical processes influence pharmaceutical product development and efficacy.

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

Course Outcomes (COs)	Course Outcome Statements
MSCBS01.CO1	Analyse biomolecular structure and function for biological and pharmaceutical relevance.
MSCBS01.CO2	Evaluate enzyme kinetics and regulation in drug development.
MSCBS01.CO3	Apply biochemical energetics to metabolic processes in biopharmaceutics.
MSCBS01.CO4	Assess metabolic pathways and disorders to identify therapeutic targets.
MSCBS01.CO5	Integrate biochemical insights to address biopharmaceutical challenges.

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, specialised, and professional tasks relating to teaching, research and development.	**PO-2** Demonstrate acquiring advanced cognitive and technical skills required for evaluating research findings and designing and conducting research in Biopharmaceutical Science.	**PO-3** Apply advanced knowledge of research methods to conduct research and investigations to formulate evidence-based solutions to complex and unpredictable problems in Biopharmaceutical Science.	**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 Biopharmaceutical Science, by following basic research ethics.
MSCBS01.CO1	3	3	2	2
MSCBS01.CO2	3	3	3	2
MSCBS01.CO3	2	3	2	1
MSCBS01.CO4	3	3	3	2
MSCBS01.CO5	3	3	3	3

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						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)	
MSCBS01	PCC	Biochemistry	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 functions and significance of carbohydrates and lipids in biological systems. *TSO 1b.* Classify biomolecules based on their chemical properties and functions. *TSO 1c.* Differentiate between the structures of monosaccharides, fatty acids, amino acids, and nucleotides. *TSO 1d.* Explain the role of functional groups in determining the properties of biomolecules. *TSO 1e.* Identify examples of medications that are derived from or target specific biomolecules. *TSO 1f.* Describe the four levels of protein structure and their significance to function. *TSO 1g.* Assess the unique properties of proteins and nucleic acids that contribute to their roles in pharmaceuticals.	**Unit-1.0 Biomolecules, Proteins and Nucleic Acids** 1.1 Biomolecules: Carbohydrates, Lipids, 1.2 Chemistry and Classification, 1.3 Structures of biomolecules, 1.4 Biochemical properties, 1.5 Pharmaceutical Importance. 1.6 Protein and Nucleic Acids: Structure (primary, secondary, tertiary and quaternary) 1.7 Properties, pharmaceutical importance	**CO1**
TSO 2a. Illustrate enzyme kinetics by calculating reaction rates using the Michaelis-Menten equation. *TSO 2b.* Explain the mechanisms of enzyme inhibition and the role of allosteric regulators in enzyme activity. *TSO 2c.* Explain the concept of allosteric regulation and its physiological significance. *TSO 2d.* Describe the organisation and function of multienzyme systems in metabolic regulation. *TSO 2e.* Identify food sources rich in specific vitamins acting as coenzymes. *TSO 2f.* Illustrate the role of NAD/NADP in cellular respiration. *TSO 2g.* Analyze the consequences of cofactor deficiencies on enzyme activity	**Unit-2.0 Enzymes** 2.1 Enzymes: Classification, mode of action (activation, specificity), enzyme kinetics 2.2 Enzyme inhibitors and regulators 2.3 Allosteric enzymes, isoenzymes 2.4 Multienzyme systems and pharmaceutical importance. 2.5 Coenzymes and Cofactors: Coenzymes, Classification of Vitamins 2.6 Role and mechanism of action of some important coenzymes (NAD /NADP, FAD, lipoic acid, tetrahydrofolate, B12 coenzyme) 2.7 Role of cofactors with specific examples	**CO2**
TSO 3a. Explain the relationship between free energy and the freedom of reactions. *TSO 3b.* Explain the relevance of thermodynamic laws to biological systems. *TSO 3c.* Solve problems applying thermodynamics principles to biochemical reactions. *TSO 3d.* Explain the energy profiles of exergonic vs. endergonic reactions. *TSO 3e.* Compare the energy content of different energy-rich molecules.	**Unit- 3.0: Biochemical Energetics** 3.1 Free energy, concept of standard free energy 3.2 Laws of thermodynamics 3.3 Exergonic and endergonic reactions. 3.4 Energy-rich compounds 3.5 Coupling of reactions 3.6 Biological oxidation-reduction	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 3f. Interpret an electron transport chain sequence and its energy-yielding steps.		
TSO 4a. Differentiate between glycolysis and gluconeogenesis. *TSO 4b.* Differentiate between the TCA cycle and the glyoxylate cycle in terms of intermediates and biological significance. *TSO 4c.* Explain the role of insulin and glucagon in regulating glucose metabolism. *TSO 4d.* Explain chemiosmotic theory and the proton-motive force. *TSO 4e.* Compare different glycogen storage diseases and their biochemical defects. *TSO 4f.* Distinguish the substrates and products of α- and ω-oxidation. *TSO 4g.* Analyze the reciprocal regulation of fatty acid synthesis and oxidation	**Unit-4.0: Carbohydrates, Lipid Metabolism** 4.1 Carbohydrate metabolism: Glycolysis, gluconeogenesis 4.2 Pentose phosphate pathways (PPP), glycolysis, TCA cycle, glyoxylic acid cycle, 4.3 Regulation of carbohydrate metabolism 4.4 Electron transport chain and oxidative phosphorylation 4.5 Disorders of carbohydrate metabolism. 4.6 Lipid metabolism: Hydrolysis, absorption and transport of lipids, 4.7 catabolism of lipids, α-, β-and ω-oxidation of fatty acids 4.8 ketone bodies formation, biosynthesis of fatty acids 4.9 Disorders of lipid metabolism.	**CO4**
TSO 5a. Illustrate the steps involved in the hydrolysis of a specific protein in a biological context. *TSO 5b.* Analyse the interrelationships between various amino acids in metabolic pathways. *TSO 5c.* Illustrate the process of amino acid biosynthesis with specific examples. *TSO 5d.* Explain nucleotide formation via biosynthesis in a given cell type. *TSO 5e.* Analyze the efficiency of salvage pathways in different organisms. *TSO 5f.* Describe the mechanisms through which ribonucleotide reductase converts ribonucleotides to deoxyribonucleotides. *TSO 5g.* Analyze case studies of patients with disorders of purine metabolism and their treatment options. *TSO 5h.* Evaluate treatment strategies for managing disorders of purine and pyrimidine metabolism.	**Unit- 5.0: Protein, Nucleic Acid Metabolism** 5.1 Protein metabolism: Hydrolysis of proteins 5.2 pathways of amino acid degradation, and urea 5.3 Cycle and formation of uric acid, assimilation of ammonia, biosynthesis of amino acids, inborn error of protein metabolism 5.4 Nucleic Acid Metabolism: Purine and pyrimidine biosynthesis, 5.5 Salvage pathway, degradation of nucleotides 5.6 Role of ribonucleotide reductase, pharmaceutical importance 5.7 disorders of purine and pyrimidine metabolisms	**CO4 & CO5**

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems:

i. How do different classes of pharmaceutical compounds interact with specific biomolecular targets?
   - Literature review of 5 different drug classes and their molecular targets
   - Analysis of structure-activity relationships
   - Prediction of potential side effects based on off-target interactions
   - Proposal for improving drug specificity

ii. How does protein glycosylation affect the pharmacokinetics and pharmacodynamics of therapeutic proteins?
   - Compare glycosylated vs non-glycosylated versions of the same therapeutic protein
   - Analyse clinical data on efficacy and safety
   - Investigate biosimilar development challenges
   - Propose optimisation strategies

iii. What are the current challenges and solutions for delivering nucleic acid-based therapeutics?
   - Review different delivery systems (lipid nanoparticles, viral vectors, etc.)
   - Analyse success rates and limitations
   - Investigate recent technological advances
   - Design a novel delivery approach

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 comparative table of carbohydrates and lipids, including structure, properties, and biological roles.
- Create 3D models (software) of protein structures at different levels.
- Prepare a chart showing ATP equivalents produced in different metabolic cycles.
- Plot a graph for enzyme kinetics using hypothetical data.
- Prepare a chart classifying enzymes with examples and their pharmaceutical roles.
- Design a flowchart for glycolysis, TCA cycle, and β-oxidation with key intermediates.
- Prepare a case report on a disorder of carbohydrate metabolism (e.g., diabetes mellitus).
- Prepare a Diagram of purine and pyrimidine biosynthesis pathways

b. Seminar Topics:

- Role of biomolecules in targeted drug delivery
- Therapeutic applications of nucleic acids: mRNA vaccines as a case study
- Vitamin-derived coenzymes in clinical nutrition
- Enzymes as therapeutic agents: Current applications and future prospects

- Thermodynamic laws in living organisms
- ATP: The molecule that powers life
- Mitochondrial function in energy metabolism
- Ketone bodies: Adaptive fuel or metabolic warning sign
- Urea cycle disorders and diagnostics
- Role of nucleic acid metabolism in cancer therapeutics

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 Biomolecules, Proteins and Nucleic Acids	10
CO2	Unit 2.0 Enzymes	10
CO3	Unit 3.0 Biochemical Energetics	10
CO4	Unit 4.0 Carbohydrates, Lipid Metabolism	10
CO5	Unit 5.0 Protein, Nucleic Acid Metabolism	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.	Biopharmaceuticals: Biochemistry and Biotechnology	Gary Walsh	Publisher: Wiley-Blackwell, ISBN-10: 0470843276
2.	Lehninger Principles of Biochemistry	Nelson, D.L. and Cox, M.M., W.H. Freeman,	8th Edition (ISBN: 978-1319108241)
3.	Biochemistry	Stryer, L., Berg, J.M., and Tymoczko, J.L., W.H. Freeman,	9th Edition (ISBN: 978-1319114671)

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
4.	Harper's Illustrated Biochemistry	Rodwell, V.W.	McGraw-Hill Education, 31st Edition (ISBN: 978-1259837937)
5.	Biochemistry: The Molecular Basis of Life	McKee, T. and McKee, J.R.,	Oxford University Press, 6th Edition (ISBN: 978-0190207336)
6.	Clinical Biochemistry: Metabolic and Clinical Aspects	Marshall, W.J. and Bangert, S.K.,	Elsevier, 3rd Edition (ISBN: 978-0702051401)
7.	Enzymes: Biochemistry, Biotechnology, Clinical Chemistry	Palmer, T.,	Horwood Publishing, 2nd Edition (ISBN: 978-1898563785)
8.	Biomarkers in Drug Development	Prien, O	Springer, 1st Edition (ISBN: 978-1461477679)

b) Online Educational Resources (OER): -

Q) Course Curriculum Developer

S. No.	Name	E-mail Address
1.	Prof. Bashirulla Shaik	bshaik@nitttrbpl.ac.in

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A)	**Course Title:** Biostatistics	Deemed to be University under Distinct Category
B)	**Course Code:** MSCBS02	
C)	**Pre- requisite (s):**	

D) **Rationale:** In the era of data-driven biopharmaceutical research and development, proficiency in biostatistics and bioinformatics has become indispensable for modern scientists. This course provides students with essential statistical tools for analyzing biological data and introduces computational methods for managing and interpreting large-scale biological datasets. Students will learn to apply statistical principles to experimental design, hypothesis testing, and data interpretation in biopharmaceutical contexts.

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
MSCBS02.CO1	Apply biostatistical concepts and methods to interpret health-related data
MSCBS02.CO2	Analyze the data using correlation, regression, and hypothesis testing.
MSCBS02.CO3	Analyse biological phenomena using probability theory and statistical methods.
MSCBS02.CO4	Use sampling methods and probability distributions for real-world data analysis.
MSCBS02.CO5	Utilize advanced statistical methods in pharmaceutical and clinical research.

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, specialised, and professional tasks relating to teaching, research and development.	**PO-2** Demonstrate acquiring advanced cognitive and technical skills required for evaluating research findings and designing and conducting research in Biopharmaceutical Science.	**PO-3** Apply advanced knowledge of research methods to conduct research and investigations to formulate evidence-based solutions to complex and unpredictable problems in Biopharmaceutical Science.	**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 Biopharmaceutical Science, by following basic research ethics.
MSCBS02.CO1	2	3	3	2
MSCBS02.CO2	2	3	3	2
MSCBS02.CO3	2	3	3	2
MSCBS02.CO4	2	3	3	2
MSCBS02.CO5	3	3	3	2

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
MSCBS02	PCC	Biostatistics	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. Identify the applications of biostatistics in medical research and practice. *TSO 1b.* Explain the importance of sampling in biostatistics. *TSO 1c.* Describe different methods for graphical representation of data (histograms, bar charts, scatter plots). *TSO 1d.* Calculate the mean, median, and mode for a given dataset. *TSO 1e.* Calculate the range, variance, and standard deviation for a given dataset.	**Unit-1.0 Biostatistics** 1.1 Introduction to Biostatistics, Applications 1.2 Methods of sampling 1.3 Tabulation of data, its diagrammatic and graphical representation. 1.4 Measurement of central tendency – mean, median and average. 1.5 Measures of dispersion, variance and standard deviation, mean deviation, standard error, Range, Coefficient of variation.	**CO1**
TSO 2a. Create a graphical representation for a given set of data involving two continuous variables. *TSO 2b.* Explain the concept of correlation and its limitations. *TSO 2c.* Calculate Pearson's correlation coefficient for a dataset and determine its statistical significance. *TSO 2d.* Describe the difference between correlation and causation *TSO 2e.* Apply t-test to compare means between two groups. *TSO 2f.* Explain the principles of experimental design. *TSO 2g.* Differentiate between factor analysis and path analysis	**Unit-2.0 Correlation and Regression** 2.1 Graphical presentation of two continuous variables. 2.2 Pearson's correlation coefficient and its statistical significance. Multiple and partial correlations. 2.3 Correlation and Regression, analysis, correlation and regression coefficients. 2.4 Linear regression and regression equation. 2.5 Test and types of significance, t-test, chi-square test and analysis of variance, F-test. 2.6 Design of experiment, randomisation, replication, local control, complementary randomised block design. 2.7 Factor analysis, path analysis.	**CO2**
TSO 3a. Describe classical and modern probability concepts. *TSO 3b.* Explain concepts of cumulative and relative frequency. *TSO 3c.* Explain the significance of cumulative and relative frequency in data analysis. *TSO 3d.* Analyse the relationship between two variables through correlation analysis. *TSO 3e.* Explain the concepts of sample space and event types in probability. *TSO 3f.* Interpret different types of events and their axioms in probability theory.	**Unit-3.0 Probability Theory** 3.1 Classical and modern definition of probability, frequency distribution 3.2 Cumulative and relative frequency 3.3 Correlation, covariance, correlation analysis and coefficient. 3.4 Sample space and events, independent events, mutually exclusive events, axioms of probability 3.5 Conditional Probability, Additional and Multiplication Theorem of Probability	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 3g. Analyse correlation coefficients and covariance in biological datasets. *TSO 3h.* Explain Bayes' theorem and its practical relevance in biological data analyses. *TSO 3i.* Summarise the principles of maximum likelihood estimation in biological research contexts.	3.6 Baye's theorem and its application in Biology 3.7 Maximum likelihood method	
TSO 4a. Describe sampling errors and its implications. *TSO 4b.* Explain the concept of sampling distribution and its importance in inferential statistics. *TSO 4c.* Interpret the sampling distribution of the sample mean and sample proportion. *TSO 4d.* Calculate probabilities using the binomial distribution. *TSO 4e.* Calculate probabilities using the Poisson distribution for rare events. *TSO 4f.* Apply the Poisson approximation to solve problems involving large sample sizes and small probabilities. *TSO 4g.* Describe the properties of the normal distribution and its significance in statistics.	**Unit-4.0 Sampling and Theory of Probability Distribution** 4.1 Objective of sampling, 4.2 Sampling error, Methods of sampling, Sampling distribution, 4.3 Sampling distribution of sample means and sample proportion, Standard error. 4.4 Binomial distribution 4.5 Poisson distribution 4.6 Poisson approximation to the Binomial distribution 4.7 Normal and Standard Normal Distribution	**CO4**
TSO 5a. Conduct a Mann-Whitney U test on a given dataset *TSO 5b.* Analyze pre- and post-treatment scores using the Wilcoxon matched pair test. *TSO 5c.* Distinguish between Kruskal-Wallis and Friedman tests in the context of independent and related samples. *TSO 5d.* Calculate Spearman's rank correlation for a given set of paired data. *TSO 5e.* Describe the importance of randomisation and control in clinical trial design. *TSO 5f.* Compare the statistical power of parallel versus crossover designs in similar trials. *TSO 5g.* Perform a bioequivalence analysis using the relevant statistical tests given the sample data.	**Unit 5.0 Statistical Techniques in Pharmaceutics** 5.1 Non-parametric tests: Sign; Mann-Whitney U 5.2 Wilcoxon matched pair 5.3 Kruskal-Wallis and Friedman two-way 5.4 ANOVA tests. 5.5 Spearman rank correlation. 5.6 Experimental design in clinical trials 5.7 Parallel crossover designs. 5.8 Statistical test for bioequivalence. 5.9 Dose response studies, Statistical quality control	**CO5**

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems:

i. Pharmaceutical Quality Control Analysis:
- Analyse tablet weight variation data from a manufacturing batch using appropriate statistical measures and determine if the batch meets specifications.

ii. Bioequivalence Study Design:
- Design and analyse a crossover bioequivalence study comparing generic and branded formulations of a cardiovascular drug.

iii. Clinical Trial Data Analysis:
- Evaluate the efficacy of a new antidiabetic drug using paired t-test and appropriate non-parametric alternatives for before-after treatment comparisons.

iv. Drug Stability Studies:
- Apply regression analysis to predict the shelf-life of pharmaceutical products based on accelerated stability testing data.

v. Adverse Drug Reaction Monitoring:
- Use Bayes' theorem to calculate posterior probabilities of drug-induced adverse events based on prior knowledge and new clinical evidence.

vi. Manufacturing Process Optimisation:
- Apply factorial design principles to optimise formulation parameters for sustained-release tablets.

vii. Pharmacokinetic Data Modelling:
- Analyse plasma concentration-time data using appropriate statistical methods to determine pharmacokinetic parameters.

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): (Seminar Topics/ Visits/ Self- Learning Topics)

Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.
- Data visualisation and descriptive statistics using pharmaceutical manufacturing.
- Correlation and regression analysis of dose-response relationships
- Probability calculations in drug safety assessment scenarios
- Comparative analysis using parametric and non-parametric tests
- Clinical trial design proposal with statistical justification

b. Seminar Topics:

- Statistical considerations in drug development phases
- Regulatory guidelines for statistical analysis in pharmaceutical submissions
- Meta-analysis in pharmaceutical research
- Adaptive clinical trial designs
- Statistical methods in pharmacovigilance
- Big data analytics in pharmaceutical research
- Machine learning applications in drug discovery

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

COs	Relevant Unit Number and Title	Marks
CO1	Unit 1.0: Introduction to Biostatistics	08
CO2	Unit 2.0: Correlation and Regression	12
CO3	Unit 3.0: Probability Theory	08
CO4	Unit 4.0: Sampling and Theory of Probability Distribution	10
CO5	Unit 5.0 Statistical Techniques in Pharmaceutics	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:

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.	Statistical Package Software	Excel, R, MATLAB	All

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Fundamentals of Biostatistics	Bernard Rosner	ISBN: 1305465512, 9781305465510 Publisher: Cengage Learning, 2015
2.	Pharmaceutical Statistics: Practical and Clinical Applications by	Bolton and Bon	5th Edition Boca Raton eBook ISBN9780429147678
3.	Statistical Misconceptions	Schuyler W. Huck	Taylor & Francis Inc ISBN: 9780805859041
4.	Biostatistics: A Foundation for Analysis in the Health Sciences	Wayne W. Daniel, Chad L. Cross	Wiley, ISBN: 978-1118302798)
5.	Introduction to Biostatistics	Robert R. Sokal, F. James Rohlf - W.H. Freeman	ISBN: 978-0716724117
6.	Biostatistics for the Biological and Health Sciences	Marc M. Triola, Mario F. Triola, Jason Roy	Pearson (ISBN: 978-0134039916)

b) Online Educational Resources (OER):

1) FDA Guidance Documents:https://www.fda.gov/drugs/guidance-compliance-regulatory-information/guidances-drugs
2) EMA Guidelines:https://www.ema.europa.eu/en/human-regulatory/research-development/scientific-guidelines
3) ICH Guidelines:https://www.ich.org/products/guidelines.html
4) WHO Technical Reports:https://www.who.int/publications/technical-report-series
5) BioPharma International:https://www.biopharminternational.com/
6) Nature Biotechnology:https://www.nature.com/nbt/

Q) Course Curriculum Developer

S. No.	Name	E-mail Address
1.	Prof. Bashirulla Shaik	bshaik@nitttrbpl.ac.in

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A)	**Course Title:** Human Physiology	Deemed to be University under Distinct Category
B)	**Course Code:** MSCBS03	
C)	**Pre- requisite (s):**	

D) **Rationale:** Human Physiology forms the foundation for understanding biopharmaceutical sciences by providing comprehensive knowledge of normal physiological processes and their regulatory mechanisms. This course integrates anatomical structures with functional aspects of human organ systems, emphasising their relevance to drug development, therapeutic interventions, and biopharmaceutical applications. Students will gain insights into physiological principles underlying drug absorption, distribution, metabolism, and excretion (ADME), preparing them for advanced studies in pharmacology, drug delivery systems, and therapeutic development. The course specifically addresses how physiological knowledge translates to biopharmaceutical innovations, diagnostic applications, and therapeutic strategies for various diseases.

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

Course Outcomes (COs)	Course Outcome Statements
MSCBS03.CO1	Analyse organ system functions and their role in maintaining homeostasis.
MSCBS03.CO2	Evaluate nervous and musculoskeletal mechanisms for drug targeting and therapeutic use.
MSCBS03.CO3	Evaluate endocrine and urogenital functions in drug metabolism and therapy.
MSCBS03.CO4	Apply sensory physiology to drug effects and therapeutic delivery.
MSCBS03.CO5	Assess the effectiveness of biopharmaceutical interventions for systemic disorders.

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, specialised, and professional tasks relating to teaching, research and development.	**PO-2** Demonstrate acquiring advanced cognitive and technical skills required for evaluating research findings and designing and conducting research in Biopharmaceutical Science.	**PO-3** Apply advanced knowledge of research methods to conduct research and investigations to formulate evidence-based solutions to complex and unpredictable problems in Biopharmaceutical Science.	**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 Biopharmaceutical Science, by following basic research ethics.
MSCBS03.CO1	2	2	2	1
MSCBS03.CO2	2	3	3	1
MSCBS03.CO3	2	3	3	1
MSCBS03.CO4	2	2	3	2
MSCBS03.CO5	3	3	3	2

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
MSCBS03	PCC	Human Physiology	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. Differentiate between the nutritional values of micronutrients and their impact on overall health. *TSO 1b.* Describe the mechanics of respiration and the gas exchange principles involved. *TSO 1c.* Illustrate the process of oxygen and CO_2 transport within the bloodstream. *TSO 1d.* Describe the structure and function of the heart and blood vessels in relation to circulation. *TSO 1e.* Analyze various cardiac disorders and their physiological effects on the cardiovascular system.	**Unit-1.0 Digestive, Respiratory, and Cardiovascular Systems** 1.1 Digestive System: Anatomy and functions of the alimentary canal and digestive glands, Digestive processes in the oral cavity, stomach, and intestine, Enzyme secretions and their functions, Nutritional value of micronutrients, BMR, and nutritional disorders 1.2 Respiratory System: Functional anatomy of the respiratory system, Pulmonary and alveolar ventilation, Mechanics of respiration, gas exchange principles, Oxygen & CO_2 transport, dissociation curves, Regulation of respiration, artificial respiration, Respiratory disorders relevant to drug administration 1.3 Cardiovascular System: Components and functions of blood and plasma, Blood groups, Rh factor, Structure and function of heart and blood vessels, Cardiac cycle, cardiac output, ECG and regional circulations, Disorders of the cardiovascular system	**CO1**
TSO 2a. Explain the structure and function of neurons and glial cells, and describe how synapses facilitate nerve impulse transmission. *TSO 2b.* Compare and contrast synaptic modulation and neuromodulation, discussing their implications for neural communication. *TSO 2c.* Describe the role of neurotransmitters in sensory systems. *TSO 2d.* Illustrate the effects of specific neurotransmitters on sensory perception using case studies or examples. *TSO 2e.* Analyze the relationship between bone structure and its functional implications in various physical activities or injuries. *TSO 2f.* Explain the significance of muscle contraction processes in relation to health and disease, particularly osteoporosis. *TSO 2g.* Analyze the efficiency and effectiveness of various drug delivery methods (IM,	**Unit-2.0 Nervous and Musculoskeletal Systems** 2.1 Nervous System: Organisation of CNS, PNS, somatic and autonomic nervous systems, Enteric nervous system, Neuron and glial cell structure and function, Synapse and nerve impulse transmission, Voltage- and neurotransmitter-gated ion channels, Synaptic modulation and neuromodulation 2.2 Neurotransmitters and their mechanisms, Role in sensory systems and drug targeting 2.3 Musculoskeletal System: Skeletal system components and organisation, Bone structure, growth, and	**CO2**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
subcutaneous) in relation to muscle contraction therapies.	remodelling, Muscle types: skeletal, cardiac, and smooth 2.4 Muscle contraction: mechanism and biochemistry, Relevance to drug delivery (IM, subcutaneous routes) and osteoporosis therapies	
TSO 3a. Explain the mechanism of urine formation and the regulatory processes involved in maintaining homeostasis. *TSO 3b.* Distinguish between various types of homeostatic imbalances and their physiological implications. *TSO 3c.* Explain the methods and significance of in-vitro fertilization and assess its implications for fertility regulation. *TSO 3d.* Describe the functions of key hormones produced by the pituitary, thyroid, adrenal, parathyroid glands, and pancreas. *TSO 3e.* Analyze the interrelationships between different hormones and their regulatory roles within the endocrine system. *TSO 3f.* Explain the biochemical pathways involved in hormone signalling and their effects on target tissues. *TSO 3g.* Evaluate the biochemical differences between various hormone actions and their implications for drug design.	**Unit-3.0 Uro-genital and Endocrine Systems** 3.1 Uro-genital System: Structure and function of kidney and nephron, Mechanism and regulation of urine formation, Homeostatic imbalances and haemodialysis. 3.2 Reproductive cycles and fertilisation, Embryogenesis, fetal development, placentation, In-vitro fertilisation, fertility regulation 3.3 Endocrine System: Histology and functions of pituitary, thyroid, adrenal, parathyroid, pancreas, Peptide vs. steroid hormones 3.4 Biochemistry of hormone action, Hormonal regulation and disorders, Role of hormones in drug targeting and delivery	**CO3**
TSO 4a. Explain the processes involved in eye movements, accommodation, and pupillary reflexes. *TSO 4b.* Differentiate between various types of visual processing occurring in the cortex. *TSO 4c.* Implement techniques to assess hearing function using knowledge of the auditory system. *TSO 4d.* Explain the fundamental differences and similarities between taste and smell in terms of sensory perception. *TSO 4e.* Utilize knowledge of taste and smell pathways to analyze food preferences and aversions. *TSO 4f.* Identify key neuropharmacological concepts related to sensory pathways. *TSO 4g.* Explain the challenges associated with delivering drugs to the sensory systems efficiently.	**Unit-4.0 Sensory Systems and Signal Transduction** 4.1 Sensory Systems: optics of vision, retina, visual pathways, cortex processing, Eye movements, accommodation, pupillary reflexes 4.2 Hearing: tympanic membrane, ossicular system, cochlea, Central auditory mechanisms 4.3 Taste and smell receptors and neural pathways 4.4 Relevance to Biopharma: Mechanism of drug effects on sensory pathways, Neuropharmacology and CNS-active drugs 4.5 Delivery of therapeutics for sensory disorders	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 4h. Illustrate the application of specific delivery methods in treating sensory disorders.		
TSO 5a. Differentiate between normal and pathological states of systemic responses. *TSO 5b.* Describe the physiological factors that influence drug absorption and metabolism. *TSO 5c.* Compare pharmacokinetic profiles of two drugs and their effects on therapeutic outcomes. *TSO 5d.* Explain the rationale behind choosing specific biopharmaceutical interventions for systemic disorders. *TSO 5e.* Describe the role of various bioinstrumental techniques in assessing physiological functions. *TSO 5f.* Utilize diagnostic tools to assess physiological parameters in a clinical setting.	**Unit-5.0: Integrated System Physiology** 5.1 Integration of cardiovascular, respiratory, renal, endocrine, and nervous system function, Homeostatic regulation and systemic responses 5.2 Physiological basis of drug absorption, distribution, metabolism, excretion (ADME) 5.3 Physiological parameters influencing pharmacokinetics and pharmacodynamics 5.4 Overview of systemic disorders and their biopharmaceutical interventions, 5.5 Application of physiological knowledge in diagnostics and bioinstrumentation	**CO5**

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

i. Cardiovascular Drug Delivery: Investigate the effect of cardiac output variations on drug distribution in different disease states using computational modeling.
ii. Respiratory Therapeutics: Design and optimize inhalation drug delivery systems for treating pulmonary diseases, considering particle size and deposition patterns.
iii. Neurological Interventions: Develop strategies to enhance blood-brain barrier permeability for CNS drug delivery using physiological modulators.
iv. Renal Drug Elimination: Study the impact of kidney disease on drug clearance and develop dosing algorithms for patients with varying degrees of renal impairment.
v. Endocrine Therapeutics: Create hormone-responsive drug delivery systems that mimic natural circadian rhythms for diabetes management.
vi. Sensory Biomarkers: Develop physiological sensor-based systems for real-time monitoring of drug effects and therapeutic responses.
vii. Integrated Physiology: Use systems biology approaches to model drug interactions across multiple organ systems in aging populations.

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) SuggestedTerm Work (TW):

a. Assignment(s):

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

- Analyse the physiological alterations in a selected disease state (e.g., heart failure, COPD, or diabetes) and propose appropriate biopharmaceutical intervention strategies based on mechanistic understanding.
- Evaluate the physiological basis of a specific therapeutic target (e.g., ion channel, hormone receptor, enzyme) and design a conceptual drug development strategy including delivery route, dosage form, and patient considerations.
- Calculate and interpret pharmacokinetic parameters (e.g., half-life, clearance, volume of distribution, bioavailability) for different classes of drugs using provided or simulated data.
- Create detailed flowcharts or systems biology models to depict interactions between organ systems (e.g., cardiovascular–renal, endocrine–nervous) relevant to the pharmacological management of complex conditions.

b. Seminar Topics:

- Physiological Barriers to Drug Delivery: Challenges and Solutions
- Circadian Rhythms in Drug Metabolism: Chronopharmacology Applications
- Age-Related Physiological Changes and Their Impact on Drug Therapy
- Physiological Modeling in Drug Development: From Bench to Bedside
- Personalized Medicine: Physiological Factors in Drug Response Variability
- Biomarkers in Physiological Assessment for Drug Development
- Systems Physiology Approach to Understanding Drug Interactions

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

COs	Relevant Unit Number and Title	Marks
CO1	Unit 1.0 Digestive, Respiratory and Cardiovascular System	10
CO2	Unit 2.0 Nervous and Musculoskeletal Systems	10
CO3	Unit 3.0 Uro-genital and Endocrine Systems	10
CO4	Unit 4.0 Sensory Systems and Signal Transduction	08
CO5	Unit 5.0 Integrated System Physiology and Homeostasis	12
Total		**50**

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: (Not Applicable)

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition withISBN
1.	Human Physiology: From Cells to Systems	Lauralee Sherwood	Cengage Learning, ISBN: 978-1285866932
2.	Vander's Human Physiology	Eric Widmaier, Hershel Raff, Kevin Strang	McGraw-Hill Education, ISBN: 978-1259294099
3.	Ganong's Review of Medical Physiology	Kim Barrett, Susan Barman, Jason Yuan	McGraw-Hill Education, ISBN: 978-1259254895
4.	Physiology	Linda Costanzo	Elsevier, ISBN: 978-0323511896
5.	Principles of Physiology for the Anaesthetist	Peter Kam, Ian Power, Michael Cousins	Oxford University Press ISBN: 978-0198768647
6.	Clinical Physiology of Acid-Base and Electrolyte Disorders	Burton Rose, Theodore Post	McGraw-Hill Education ISBN: 978-0071346092
7.	Respiratory Physiology: The Essentials	John West	Lippincott Williams & Wilkins ISBN: 978-1451187625
8.	Cardiovascular Physiology Concepts	Richard Klabunde	Lippincott Williams & Wilkins ISBN: 978-1451113846

b) Online Educational Resources (OER):

1) Khan Academy Medicine:https://www.khanacademy.org/science/health-and-medicine
2) Physiopedia:https://www.physio-pedia.com/
3) Interactive Physiology:https://www.pearsonmylabandmastering.com/northamerica/masteringaandp/
4) GetBodySmart:https://www.getbodysmart.com/
5) Anatomy & Physiology OpenStax:https://openstax.org/details/books/anatomy-and-physiology

c) MOOCs (SWAYAM Links):

1) Introduction to Human Physiology - https://swayam.gov.in/nd1_noc20_bt05/preview
2) Fundamentals of Human Physiology - https://swayam.gov.in/nd1_noc19_bt05/preview
3) Systems Physiology - https://swayam.gov.in/nd1_noc20_bt15/preview

Q) Course Curriculum Developer

S. No.	Name	E-mail Address
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A)	**Course Title:** Biopharmaceuticals	Deemed to be University under Distinct Category
B)	**Course Code:** MSCBS04	
C)	**Pre- requisite (s):**	

D) **Rationale:** Biopharmaceuticals represent the fastest-growing pharmaceutical industry segment, revolutionising healthcare through innovative biological therapies. This course provides a comprehensive understanding of biopharmaceutical development, from discovery to market, encompassing modern biotechnology applications, regulatory frameworks, and manufacturing processes. Students will gain expertise in various biopharmaceutical modalities, including vaccines, antibodies, cell and gene therapies, preparing them for careers in the rapidly expanding biopharmaceutical sector while addressing critical healthcare challenges in India and globally.

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
MSCBS04.CO1	Analyse the biopharmaceutical drug discovery and development process.
MSCBS04.CO2	Evaluate biopharmaceutical types, uses, and approval trends.
MSCBS04.CO3	Design biopharmaceutical manufacturing with a focus on process, quality, and compliance.
MSCBS04.CO4	Examine challenges in biopharmaceuticals and propose innovative solutions.

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, specialised, and professional tasks relating to teaching, research and development.	**PO-2** Demonstrate acquiring advanced cognitive and technical skills required for evaluating research findings and designing and conducting research in Biopharmaceutical Science.	**PO-3** Apply advanced knowledge of research methods to conduct research and investigations to formulate evidence-based solutions to complex and unpredictable problems in Biopharmaceutical Science.	**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 Biopharmaceutical Science, by following basic research ethics.
MSCBS04.CO1	3	3	2	1
MSCBS04.CO2	2	3	2	1
MSCBS04.CO3	3	3	3	1
MSCBS04.CO4	2	3	3	2

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
MSCBS04	PCC	Biopharmaceuticals	45	15	-	30	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 significance of target identification and validation in drug development. *TSO 1b.* Establish the process of lead optimization through case studies. *TSO 1c.* Use examples to illustrate the application of companion diagnostics in treatment plans. *TSO 1d.* Examine the implications of current trends on traditional drug development methodologies. *TSO 1e.* Implement synthetic biology concepts to solve specific pharmaceutical challenges. *TSO 1f.* Investigate the impact of bioprocessing on the efficiency of drug production. *TSO 1g.* Analyze the differences in biopharmaceutical perspectives between global and Indian markets. *TSO 1h.* Differentiate manufacturing processes involved in producing biopharmaceuticals versus chemopharmaceuticals.	**Unit-1.0 Introduction to Biopharmaceuticals** 1.1 Drug Discovery and Development Process: Traditional drug discovery pipeline, target identification and validation, lead optimisation, preclinical and clinical phases, and regulatory approval process 1.2 Current Trends in Drug Development: Personalised medicine, precision therapeutics, AI/ML in drug discovery, biomarkers, companion diagnostics 1.3 Role of Biotechnology in Pharmaceuticals: Recombinant DNA technology, protein engineering, synthetic biology, CRISPR/Cas systems, bioprocessing. 1.4 Concepts and Relevance of Biopharmaceuticals: Definition, scope, therapeutic advantages, market growth, global and Indian perspectives 1.5 Biopharmaceuticals vs Chemopharmaceuticals**:** Molecular complexity, manufacturing differences, stability, cost considerations, therapeutic applications.	**CO1**
TSO 2a. Explain the significance of different classification systems and regulatory definitions in the context of biopharmaceuticals. *TSO 2b.* Categorize biopharmaceuticals into appropriate market segments using specific examples. *TSO 2c.* Illustrate the process of clinical development in the creation of a biosimilar through a detailed case study. *TSO 2d.* Examine the challenges and strategies involved in market access for biosimilars and bio-betters across different regions. *TSO 2e.* Provide examples of biopharmaceuticals currently used in the treatment of infectious diseases and rare diseases.	**Unit-2.0 Classification and Applications** 2.1 Overview and Classification: Historical development, classification systems, regulatory definitions, market segments 2.2 Biosimilars and Bio-betters: Regulatory pathways, analytical comparability, clinical development, market access, case studies 2.3 Disease Applications and Therapeutic Areas: Oncology, autoimmune diseases, infectious diseases, rare diseases, preventive applications, diagnostic applications.	**CO2**
TSO 3a. Explain the role of adjuvants in vaccine efficacy.	**Unit-3.0 Biopharmaceutical Products and Technologies**	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 3b. Demonstrate the process of developing a new immunotherapy approach. *TSO 3c.* Describe the significance of antibody-drug conjugates in targeted therapy. *TSO 3d.* Investigate the differences between bispecific antibodies and traditional monoclonal antibodies. *TSO 3e.* Analyse the role of cytokines in immune response regulation. *TSO 3f.* Compare the advantages and challenges of using aptamers versus traditional antibodies in therapy.	3.1 Vaccines and Immunotherapeutics: Vaccine types, adjuvants, immunotherapy approaches, CAR-T cells, checkpoint inhibitors 3.2 Monoclonal Antibodies and Engineered Proteins: Antibody structure-function, production methods, antibody-drug conjugates, bispecific antibodies, protein engineering 3.3 **Hormones, Enzymes, and Growth Factors:** Recombinant hormones, enzyme replacement therapy, growth factors, cytokines, production and purification 3.4 **Advanced Therapeutic Modalities:** Peptide therapeutics, antisense oligonucleotides, siRNA, aptamers, delivery systems	
TSO 4a. Explain the processes involved in cell culture, fermentation, purification, and chromatography. *TSO 4b.* Describe the significance of impurity profiling and stability testing in ensuring product safety and efficacy. *TSO 4c.* Interpret data from stability tests to determine the shelf life and storage conditions of a biopharmaceutical product. *TSO 4d.* Explore case studies of biopharmaceuticals that faced stability issues, and the strategies implemented to overcome them. *TSO 4e.* Analyse the impact of bio-economy and pricing strategies on the commercialisation of biopharmaceuticals.	**Unit-4.0 Manufacturing, Challenges and Regulatory Aspects** 4.1 Biopharmaceutical Manufacturing: Upstream processing (cell culture, fermentation), downstream processing (purification, chromatography), formulation development 4.2 Quality Control and Characterisation**:** Analytical methods, impurity profiling, stability testing, batch release testing, process validation 4.3 Biopharmaceutical Challenges**:** Pharmacokinetics, biodistribution, immunogenicity, stability issues, improvement strategies. 4.4 Regulatory and Commercial Aspects**:** ICH guidelines, regulatory pathways, intellectual property, market access, bio-economy, pricing strategies	**CO4**

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems:

i. Comparative Analysis Project: Compare the development timeline, costs, and regulatory requirements for a biosimilar versus an innovative biopharmaceutical product.

ii. Manufacturing Optimization Study: Design an upstream and downstream process for producing a recombinant therapeutic protein with cost-effectiveness analysis

iii. Immunogenicity Risk Assessment: Develop a comprehensive immunogenicity prediction and mitigation strategy for a novel monoclonal antibody therapy.
iv. Market Access Analysis: Evaluate the factors affecting market penetration of biopharmaceuticals in emerging markets like India.
v. Technology Assessment: Analyze the potential of CRISPR-based gene therapies for treating a specific genetic disorder, including ethical considerations
vi. Regulatory Pathway Comparison: Compare biosimilar approval pathways across different regulatory agencies (USFDA, EMA, CDSCO)

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.

- Conduct a literature review on current trends in biopharmaceutical development targeting diseases prevalent in India.
- Analyse case studies of recent biopharmaceutical product launches to assess factors contributing to their success or failure.
- Prepare a technical report detailing the manufacturing process design of a selected biopharmaceutical product.
- Develop a regulatory dossier by drafting an abbreviated submission for a biosimilar product in compliance with relevant guidelines.

b. Seminar Topics:

- Personalized medicine approaches in biopharmaceuticals
- Artificial intelligence applications in biopharmaceutical discovery
- Sustainable manufacturing practices in biotechnology
- Ethical considerations in gene and cell therapy
- Indian biopharmaceutical industry: opportunities and challenges
- COVID-19 vaccine development: lessons learned
- Biosimilars market dynamics in developing countries
- Next-generation antibody therapeutics

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 Biopharmaceuticals	12
CO2	Unit 2.0 Classification and Applications	10
CO3	Unit 3.0 Biopharmaceutical Products and Technologies	14
CO4	Unit 4.0 Manufacturing, Challenges and Regulatory Aspects	14
Total		**50**

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: (Not Applicable)

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Biopharmaceutical Manufacturing, Volume 1: Regulatory processes	Sarfaraz Niazi Sunitha Lokesh	IOP Publishing Ltd 2021. Online ISBN: 978-0-7503-3175-3 Print ISBN: 978-0-7503-3173-9
2.	Biopharmaceuticals: Biochemistry and Biotechnology	Gary Walsh,	Wiley-Blackwell, ISBN-10: 978-0470843276
3.	Introduction to Biopharmaceutical Manufacturing Technology	Sarfaraz K. Niazi	CRC Press, ISBN: 978-1420062724
4.	Pharmaceutical Biotechnology: Fundamentals and Applications	Daan J.A. Crommelin, Robert D. Sindelar, Bernd Meibohm,	Springer, ISBN: 978-1461407799
5.	Biotechnology: Applying the Genetic Revolution	David P. Clark Nanette J. Pazdernik,	McGraw Hill, ISBN: 978-0073532295
6.	Pharmaceutical Manufacturing Handbook: Production and Processes	Shayne Cox Gad,	Wiley-Interscience, ISBN: 978-0471259572

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
7.	Regulatory Affairs for Pharmaceuticals	Michael Mathieu,	PAREXEL International Corporation, ISBN: 978-0849383263

b) Online Educational Resources (OER):

1) FDA Guidance Documents:https://www.fda.gov/drugs/guidance-compliance-regulatory-information/guidances-drugs
2) EMA Guidelines:https://www.ema.europa.eu/en/human-regulatory/research-development/scientific-guidelines
3) ICH Guidelines:https://www.ich.org/products/guidelines.html
4) WHO Technical Reports:https://www.who.int/publications/technical-report-series
5) BioPharma International:https://www.biopharminternational.com/
6) Nature Biotechnology:https://www.nature.com/nbt/

Q) Course Curriculum Developer

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

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

J) Suggested Laboratory experiences:

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

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

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

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

K) Suggested Research Based Problems

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

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

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

L) Suggested Term Work (TW):

a. Assignment(s):

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

b. Seminar Topics:

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

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

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

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

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies: Different instructional/implementation strategies may be appropriately used in online and offline modes, as per the requirement of the outcome to be achieved. Some of them are improved lecture, tutorial, case method, group discussion, industrial visits, industrial training, field trips, portfolio based, learning, role play, live demonstrations in classrooms, lab, field information and communications technology (ICT)based teaching learning, blended or flipped mode, brainstorming, expert session, video clippings, use of open educational resources (OER), MOOCs etc. To ensure learning, research-based problems may be designed and implemented.

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience /Practical Number
4.	Weka	Software Tool	14,15 & 16
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, Repositories	**CO1**

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

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

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

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

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

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

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

L) Suggested Term Work (TW):

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

b. Seminar Topics:

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

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

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. Some of them are improved lecture, tutorial, case method, group discussion, industrial visits, industrial training, field trips, portfolio based, learning, role play, live demonstrations in classrooms, lab, field information and communications technology (ICT)based teaching learning, blended or flipped mode, brainstorming, expert session, video clippings, use of open educational resources (OER), MOOCs etc. To ensure learning, research-based problems may be designed and implemented.

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

P) Suggested Learning Resources:

a) Books

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

b) Online Educational Resources (OER):

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

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

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

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

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

F) Suggested Course Articulation Matrix (CAM):

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

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

G) Teaching & Learning and Assessment Scheme:

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

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

I) Theory Session Outcomes (TSOs) and Units:

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

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

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

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

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

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

L) Suggested Term Work (TW):

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

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

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

d. Other (Any one Topic)

Suggested Seminar/ Debates on topics such as:

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

Teacher can suggest supporting material for reference and preparation.

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

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. Some of them are improved lecture, tutorial, case method, group discussion, industrial visits, industrial training, field trips, portfolio based, learning, role play, live demonstrations in classrooms, lab, field information and communications technology (ICT)based teaching learning, blended or flipped mode, brainstorming, expert session, video clippings, use of open educational resources (OER), MOOCs etc. To ensure learning, research-based problems may be designed and implemented.

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

P) Suggested Learning Resources:

a) Books

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

b) Online Educational Resources (OER):

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

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

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

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

Course Outcomes (COs)	Course Outcome Statements
NEP04.CO1	Formulate the investment plan for various situation of income & expenditure of individuals.
NEP04.CO2	Identify various Investment Options for Retirement.
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. *TSO 1c.* Explain the steps of Budgeting for the	**Unit-1.0: Basic Financial Concepts** 1.1 Personal Financial Goals 1.2 Income, Expenses, and Net Worth 1.3 Budgeting & Cash Flow Management	**CO1, CO2**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
given situation. *TSO 1d.* Explain the Cash Flow Management process for the given situation. *TSO 1e.* Explain Saving for household for the given situation. *TSO 1f.* Formulate the investment plan for the given individual. *TSO 1g.* Explain Inflation in the economy *TSO 1h.* Identify the factors effecting the Interest Rates in the economy for the given situation. *TSO 1i.* Explain the role of Bank Accounts in personal savings for the given situation. *TSO 1j.* Explain the Payment Methods. *TSO 1k.* Explain the Credit Management system for the given situation. *TSO 1l.* Explain Debt Management for the given situation. *TSO 1m.* Explain the Insurance plan for the given situation. *TSO 1n.* Formulate the investment plan for the given situation of income & expenditure of individuals.	1.4 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	**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)
situation. *TSO 2l.* Make Tax-Effective Investment Decisions for the given situation.		
TSO 3a. Explain the importance of Entrepreneurship education *TSO 3b.* Outline the Entrepreneurial Opportunities for the given product. *TSO 3c.* Outline the Entrepreneurship Support Eco-System *TSO 3d.* Identify the Business opportunities for the given situation. *TSO 3e.* Identify the steps in market survey for an enterprise. *TSO 3f.* Identify the Procedure and formalities for Bank Finance for the given situation	**Unit-3.0: Entrepreneurship Support System** 3.1 Entrepreneurship education 3.2 Achievement Motivation 3.3 Entrepreneurial Opportunities 3.4 Entrepreneurship Support Eco-System 3.5 Business opportunities Identification 3.6 Market Survey 3.7 Procedure and formalities for Bank Finance	**CO3**

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

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

L) Suggested Term Work (TW):

a. Assignment(s):

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

b. Visits:

- Arrange a visit to a tax filing consultancy nearby.

c. Group discussions on current print articles.

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

d. Self-learning topics:

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

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

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

f. Seminar Topics:

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

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

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. Some of them are improved lecture, tutorial, case method, group discussion, industrial visits, industrial training, field trips, portfolio based, learning, role play, live demonstrations in classrooms, lab, field information and communications technology (ICT)based teaching learning, blended or flipped mode, brainstorming, expert session, video clippings, use of open educational resources (OER), MOOCs etc. To ensure learning, research-based problems may be designed and implemented.

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

P) Suggested Learning Resources:

a) Books

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

b) Online Educational Resources (OER):

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

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

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

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

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

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

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

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

G) Teaching & Learning and Assessment Scheme:

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

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

I) Theory Session Outcomes (TSOs) and Units:

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

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

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

a. Cost-Benefit Analysis of Green Technologies

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

b. Optimization of Project Scheduling Using Economic Principles

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

c. Economic Viability of Renewable Energy Systems

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

d. Risk and Uncertainty in Engineering Investment Decisions

- Problem**:** How can risk analysis techniques help improve investment decision-making in engineering projects?
- Focus: Exploring methods to quantify risk and uncertainty, such as Monte Carlo simulations or sensitivity analysis, and their application in engineering economics.

e. Economic Impact of Automation in Manufacturing

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

f. Capital Budgeting and Infrastructure Development

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

g. Lifecycle Costing in Engineering Design

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

h. Sustainability vs. Profitability in Engineering Projects

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

i. Impact of Inflation on Engineering Project Costs

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

j. Economic Analysis of Infrastructure Resilience

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

k. Evaluating Engineering Project Feasibility Using Real Options Theory

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

l. Public-Private Partnerships in Engineering: Economic Considerations

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

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

L) Suggested Term Work (TW):

a. Assignment(s):

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

i. Time Value of Money (TVM) Calculations

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

ii. Cost-Benefit Analysis for a New Engineering Project

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

iii. Break-even Analysis in Manufacturing

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

iv. Capital Budgeting for Infrastructure Projects

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

v. Depreciation Methods and Their Impact on Project Economics

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

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

vi. Life-Cycle Cost Analysis of Engineering Equipment

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

vii. Sensitivity Analysis for an Engineering Project

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

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

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

ix. Economic Analysis of Renewable Energy Projects

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

x. Risk and Uncertainty in Investment Decisions

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

xi. Public-Private Partnership (PPP) Analysis

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

xii. Inventory Management and Economic Order Quantity (EOQ)

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

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

xiii. Feasibility Study of Automation in a Production Line

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

xiv. Engineering Project Financing

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

xv. Ethical and Economic Considerations in Engineering Projects

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

b. Seminar Topics:

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

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

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. Some of them are improved lecture, tutorial, case method, group discussion, industrial visits, industrial training, field trips, portfolio based, learning, role play, live demonstrations in classrooms, lab, field information and communications technology (ICT)based teaching learning, blended or flipped mode, brainstorming, expert session, video clippings, use of open educational resources (OER), MOOCs etc. To ensure learning, research-based problems may be designed and implemented.

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

P) Suggested Learning Resources:

a) Books

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

b) Online Educational Resources (OER):

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

Q) Course Curriculum Developer

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Course Curriculum Detailing- Offline Spell -2

A)	**Course Title:** Cell and Molecular Biology	Deemed to be University under Distinct Category
B)	**Course Code:** MSCBS05	
C)	**Pre- requisite (s):**	

D) Rationale: This course provides foundational knowledge in cellular and microbial biology critical to biopharmaceutical sciences. Understanding cellular structures, microbial diversity, and physiological processes is essential for developing therapeutic strategies and innovations in drug discovery, vaccine development, and diagnostic systems. The course integrates molecular cell biology with applied microbiology, aligning with the needs of biopharma industries.

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
MSCBS05.CO1	Analyze membrane structure, composition, and transport across biological membranes
MSCBS05.CO2	Evaluate the structure-function relationships of organelles and cytoskeletal components.
MSCBS05.CO3	Examine extracellular matrix components and cell adhesion mechanisms in tissue organisation.
MSCBS05.CO4	Assess protein targeting mechanisms and post-translational modifications in cellular systems.
MSCBS05.CO5	Investigate signal transduction in cellular communication and drug targeting.

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, specialised, and professional tasks relating to teaching, research and development.	**PO-2** Demonstrate acquiring advanced cognitive and technical skills required for evaluating research findings and designing and conducting research in Biopharmaceutical Science.	**PO-3** Apply advanced knowledge of research methods to conduct research and investigations to formulate evidence-based solutions to complex and unpredictable problems in Biopharmaceutical Science.	**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 Biopharmaceutical Science, by following basic research ethics.
MSCBS05.CO1	2	3	2	-
MSCBS05.CO2	2	3	2	-
MSCBS05.CO3	2	2	2	2
MSCBS05.CO4	2	3	3	-
MSCBS05.CO5	2	3	3	2

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
MSCBS05	PCC	Cell and Microbiology	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. Differentiate between the roles of the fluid mosaic model and lipid rafts in cellular processes. *TSO 1b.* Categorise different types of proteins found in a given membrane sample. *TSO 1c.* Solve a problem involving the calculation of diffusion rates across a membrane. *TSO 1d.* Investigate the role of artificial liposomes in drug delivery and their advantages. *TSO 1e.* Investigate the relationship between organelles and the cytoskeleton in cellular function and structure.	**Unit-1.0 Cellular Organisation and Membrane Biology** 1.1 Membrane models: fluid mosaic, lipid raft 1.2 Chemical composition (phospholipids, cholesterol, proteins), membrane proteins (integral, peripheral, GPI-anchored) 1.3 Membrane Transport: Small molecule transport (diffusion, facilitated diffusion, active transport) 1.4 Large molecule transport (endocytosis types, phagocytosis), osmosis principles, artificial liposomes and drug delivery applications 1.5 Sub-cellular Organelles and Cytoskeleton: Nucleus (nuclear envelope, nucleolus, chromatin), mitochondria (structure, bioenergetics), ER (rough/smooth, protein synthesis), Golgi apparatus (trafficking, modification), lysosomes (autophagy, degradation), plastids, peroxisomes, microtubules, microfilaments, motor proteins (myosin, kinesin, dynein)	**CO1**
TSO 2a. Explain the role of the ECM in tissue structure and function. *TSO 2b.* Distinguish between the functions of integrins, cadherins, and immunoglobulins in various biological contexts. *TSO 2c.* Predict the consequences of disrupting ribosomal function on protein synthesis in a specific context. *TSO 2d.* Explain the importance of post-translational modifications for protein function. *TSO 2e.* Examine the relationship between vesicular transport and cellular compartmentalisation. *TSO 2f.* Compare the mechanisms of action of different receptor types in signalling.	**Unit-2.0 Extracellular Matrix and Protein Targeting** 2.1 Function and composition of extracellular matrix molecules 2.2 Types of cell adhesion molecules, integrin, cadherin and immunoglobulin superfamily proteins. 2.3 Protein synthesis on free and bound ribosomes 2.4 Modification and quality control of protein in the ER 2.5 Secretion and transport of protein to various cell compartments, post-translational modification. 2.6 Receptors and ligands, cellular communication, signalling through membrane receptors like GPCR, receptor tyrosine kinase, receptor serine/threonine kinase, PI3K/Akt, MAPkinase, cytokine signalling like JAK-STAT, TCR-mediated signalling	**CO2**
TSO 3a. Illustrate how disturbances in the cell cycle can lead to cell growth disorders.	**Unit-3.0 Cell Cycle and Cancer** 3.1 Cell cycle, role of cyclins, cyclin-dependent kinase in cell cycle progression.	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 3b. Differentiate between necrosis and apoptosis and analyse. *TSO 3c.* Explain the mechanisms underlying necrosis and autophagy and their physiological roles. *TSO 3d.* Analyse case studies where specific genetic mutations lead to particular cancer types. *TSO 3e.* Examine the impact of viral infections on normal cell cycle regulation and the development of cancer. *TSO 3f.* Investigate the effectiveness of a specific therapeutic intervention in controlling cancer growth.	3.2 Apoptosis: pro-apoptotic and anti-apoptotic regulators 3.3 Mechanism of necrosis and autophagy. 3.4 Genetic rearrangements in progenitor cells, oncogenes, and tumour suppressor genes. 3.5 Cancer and the cell cycle, virus-induced cancer, interaction of cancer cells with normal cells 3.6 Therapeutic interventions of uncontrolled cell growth, embryonic signature in cancer cells.	
TSO 4a. Describe the significance of evolutionary theories in microbiology. *TSO 4b.* Examine the rationale behind the evolution from Haeckel's to Woese's classification system. *TSO 4c.* Differentiate between conventional and modern methods of bacterial taxonomy. *TSO 4d.* Calculate microbial growth using mathematical expressions and curves. *TSO 4e.* Compare the growth characteristics of various prokaryotic groups. *TSO 4f.* Isolate and cultivate bacteria using defined techniques. *TSO 4g.* Assess the impact of fungi and algae on food production. *TSO 4h.* Differentiate between yeast species based on their reproductive strategies.	**Unit-4.0 Microbiology and Prokaryotic and Eukaryotic Microbiology** 4.1 Origin and evolution of microbial world, Pathway of discovery in Microbiology 4.2 Haeckel's three kingdom concept, Whittaker's five kingdom concept, three domain concept of Carl Woese 4.3 Classification and bacterial and archaea systematics: conventional and modern methods of bacterial taxonomy. Classification of bacteria according to Bergey's manual, bacterial identification, general characteristics of archaea, eubacteria, and acellular life forms 4.4 Microbes Growth: Definition, mathematical expression, curve, diauxic & synchronous growth, continuous culture. 4.5 Effect of the environment on bacterial growth. General characteristics of various groups of prokaryotes: bacteria, including Rickettsiae, Chlamydiae, Spirochaetes, Actinobacteria, Cyanobacteria and Mycoplasmas. 4.6 Cell structure, nutrition, isolation and cultivation. Diversity, nutrition, ecology, significance of gram-positive (Firmicutes, Actinobacteria) and gram-negative [Proteobacteria (cyanobacteria, Rhizobia), Deinococcus-Thermus, Spirochaetes, Bacteroidetes]. 4.7 Mycology and phycology: General characters of fungi and algae, cultivation, cultural characteristics, microscopic morphology,	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
	importance of fungi and algae in industry and food production. 4.8 Yeasts: General characteristic, structure, classification, life cycles (important forms), sexual and asexual reproduction of yeast (*Saccharomyces cerevisiae)*	
TSO 5a. Illustrate the molecular structure of an animal virus and a plant virus using diagrams. *TSO 5b.* Investigate the relationship between virus structure and the diseases they cause. *TSO 5c.* Differentiate between DNA and RNA genome organization in viruses. *TSO 5d.* Illustrate the life cycle of a chosen protozoan and its modes of transmission. *TSO 5e.* Use diagrams to showcase the life cycles of Entamoeba and Plasmodium. *TSO 5f.* Investigate the benefits and challenges of using microorganisms in food production.	**Unit -5.0: Virology and Applied Microbiology** 5.1 Virology- Structure of animal viruses and plant viruses; satellite viruses; viroids; prions 5.2 Diseases caused by animal viruses and plant viruses, genome organisation of animal viruses. 5.3 Genome organisation of DNA and RNA plant viruses, bacteriophages, lytic and lysogenic cycles, cultivation of viruses, diagnosis of viruses. 5.4 Protozoa: Classification, morphology, reproduction, modes of nutrition, modes of transmission, life cycle, cultivation of protozoa. 5.5 Structure and significance: *Entamoeba*, *Plasmodium*. 5.6 Applied Microbiology Overview of applications of microorganisms in Agriculture, Environment, Food, Industry and Medical Sciences.	**CO5**

J) Suggested Laboratory experiences:

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
LSO 1.1. Use sterilisation and disinfection techniques properly. *LSO 1.2.* Apply biosafety guidelines to ensure a contamination-free and safe microbiological work environment.	1.	Sterilisation, disinfection, and safety in a microbiological laboratory	CO3
LSO 2.1. Prepare and sterilise different types of culture media (solid and liquid). *LSO 2.2.* Prepare nutrient agar plates, broth, and slants using standard protocols.	2.	Preparation of media (plates, broth and slants) for the growth of various microorganisms.	CO1
LSO 3.1. Perform streak and spread plate methods to isolate pure colonies. *LSO 3.2.* Interpret colony growth patterns for identification and selection.	3.	Identification and culturing of various microorganisms. Spreading and streaking plating techniques.	CO4
LSO 4.1. Prepare bacterial smears and apply appropriate staining protocols (simple, Gram, spore, and capsule). *LSO 4.2.* Apply appropriate staining methods.	4.	Staining of bacteria – Simple staining, differential staining, staining of spores and capsules	CO4

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
LSO 5.1. Quantify viable microorganisms in water samples using serial dilution and plate count techniques *LSO 5.2.* Interpret results to evaluate microbial contamination levels.	5.	Enumeration of microorganisms from water by viable plate counting	CO4
LSO 6.1. Monitor bacterial growth over time using spectrophotometry. *LSO 6.2.* Plot and interpret bacterial growth curve phases (lag, log, stationary, decline). *LSO 6.3.* Calculate bacterial population using optical density values.	6.	Determination of the growth curve of bacteria and calculation of bacterial population by turbidometry	CO4
LSO 7.1. Analyse bacterial growth response under varying pH, temperature, and UV conditions. *LSO 7.2.* Determine optimal growth conditions for selected bacteria.	7.	Effect of pH, temperature and UV irradiation in bacterial growth	CO4, CO5
LSO 8.1. Perform broth or agar dilution methods to assess MIC values. *LSO 8.2.* Interpret MIC results to evaluate the antibiotic sensitivity of bacterial strains.	8.	Determination of Minimal Inhibitory concentrations (MIC) for kanamycin and ampicillin against Bacteria.	CO4, CO5

K) Suggested Research Based Problems

i. Explore signalling pathway crosstalk in immune response.
ii. Design and characterize targeted liposomal drug delivery systems.
iii. Investigate mitochondrial dysfunction in disease models
iv. Analyze dysregulated signaling pathways in cancer cell lines.
v. Study genetic mutations affecting protein targeting
vi. Examine extracellular matrix changes in tissue engineering 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.

- Prepare a comprehensive comparative analysis report by examining passive diffusion, facilitated diffusion, and active transport mechanisms across biological membranes, evaluating their respective roles in drug delivery systems and proposing optimization strategies for enhancing therapeutic efficacy.

- Conduct a detailed literature review investigating the molecular mechanisms of organellar biogenesis (mitochondria, endoplasmic reticulum, and Golgi apparatus), analysing their dysfunction in human diseases, and discussing current pharmaceutical interventions targeting organellar pathways.
- Analyze a specific case study of signal transduction pathway targeting in cancer therapeutics, examining the molecular basis of pathway dysregulation, evaluating current therapeutic approaches, and proposing novel intervention strategies based on recent research findings in a report form.

b. Seminar Topics:

- Emerging technologies in membrane protein crystallization
- Autophagy modulation as therapeutic strategy
- CRISPR applications in signal transduction studies
- Extracellular vesicles in drug delivery
- Organelle-targeted therapeutics

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 Cellular Organisation and Membrane Biology	10
CO2	Unit 2.0 Extracellular Matrix and Protein Targeting	10
CO3	Unit 3.0 Cell Cycle and Cancer	8
CO4	Unit 4.0 Microbiology and Prokaryotic and Eukaryotic Microbiology	10
CO5	Unit 5.0 Virology and Applied Microbiology	12
Total		**50**

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.	Autoclave	Autoclave: 121°C, 15 psi	All
2.	Hot Air Oven	Oven: up to 250°C	All
3.	Laminar Air Flow Hood	LAF: HEPA-filtered airflow	All
4.	Microscope	Microscope: 1000x (oil immersion), Abbe condenser	All
5	Incubator	incubator: 25–37°C range	All
6	pH Meter	pH meter (±0.01 accuracy)	All
7	Weighing Balance	Balance (0.1 mg precision)	All
8	Spectrophotometer (UV-Vis)	ELISA Reader/Microplate Reader	All
9	ELISA Reader/Microplate Reader	Reader: 405–650 nm range	All

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Molecular Biology of the Cell	Bruce Alberts et al.	Garland Science ISBN: 978-0815344643
2.	Cell Biology	Gerald Karp	Wiley Publishers ISBN: 978-1118464984
3.	Lehninger Principles of Biochemistry	David L. Nelson, W.H. Freeman	ISBN: 978-1464126116
4.	The Cell - A Molecular Approach,	G.M. Cooper.	Sunderland (MA), Sinauer Associates, Inc. USA. 2013.
5.	Microbiology	Michael J Pelczar	Tata McGraw, India.
6.	Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses.	S. J. Flint, V. R. Racaniello, L. W. Enquist, V. R. Rancaniello, A. M. Skalka	-
7.	Molecular Cell Biology	Lodish, H., Berk A., Kaiser C. A., Krieger M., Bretscher A., Ploegh H., and Scott M.P.	7th Edition, Freeman, W. H. and Co., 2013.
8.	Molecular Biology of the Cell,	Alberts B., Walter P., Johnson A., Lewis J., Morgan D., and Raff. M., RobertsK., Walter P	6th Edition, Garland Publishing Inc., 2014.
9.	The Cell: A Molecular Approach	Geoffrey M. Cooper,	Sinauer Associates ISBN: 978-1605357072
10.	Signal Transduction	Wendell Lim et al.,	Garland Science ISBN: 978-0815342816

Q) Course Curriculum Developer

S. No.	Name	E-mail Address
1.	Prof. Bashirulla Shaik	bshaik@nitttrbpl.ac.in

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A)	**Course Title:** Bioinformatics	Deemed to be University under Distinct Category
B)	**Course Code:** MSCBS06	
C)	**Pre- requisite (s):**	

D) **Rationale:** The Bioinformatics course is designed to provide students with essential computational skills and theoretical knowledge required to analyse biological data in the context of biopharmaceutical sciences. With the exponential growth of genomic and proteomic data, bioinformatics has become indispensable for drug discovery, protein engineering, and understanding molecular mechanisms of diseases. This course bridges the gap between biological sciences and computational methods, enabling students to utilise databases, analyse sequences, predict protein structures, and apply computational approaches to solve real-world problems in biopharmaceutical research and development. The course emphasises hands-on experience with industry-standard tools and databases, preparing students for careers in pharmaceutical industries, research institutions, and biotechnology companies.

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
MSCBS06.CO1	Apply Core bioinformatics concepts and effectively use biological databases.
MSCBS06.CO2	Relate protein sequence variation to functional specialisation
MSCBS06.CO3	Assess molecular recognition and protein structural principles.
MSCBS06.CO4	Select suitable algorithms for sequence alignment tasks
MSCBS06.CO5	Evaluate the role of structural genomics in drug discovery.

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, specialised, and professional tasks relating to teaching, research and development.	**PO-2** Demonstrate acquiring advanced cognitive and technical skills required for evaluating research findings and designing and conducting research in Biopharmaceutical Science.	**PO-3** Apply advanced knowledge of research methods to conduct research and investigations to formulate evidence-based solutions to complex and unpredictable problems in Biopharmaceutical Science.	**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 Biopharmaceutical Science, by following basic research ethics.
MSCBS06.CO1	3	3	2	1
MSCBS06.CO2	2	3	2	1
MSCBS06.CO3	2	3	3	1
MSCBS06.CO4	2	3	2	1
MSCBS06.CO5	3	3	3	2

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
MSCBS06	PEC	Bioinformatics	45	15	-	30	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, and 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 information chaos and its implications for biological research. *TSO 1b.* Compare and contrast different challenges faced by researchers in the postgenomic era. *TSO 1c.* Use specific databases to retrieve biological information relevant to a biopharmaceutical research question. *TSO 1d.* Access structural and gene databases to retrieve relevant data for a given question. *TSO 1e.* Describe how to effectively utilise searching tools for biological data retrieval. *TSO 1f.* Use EBI resources to answer a specific biological research question. *TSO 1g.* Describe the principles behind Alphafold and its significance in structural biology.	**Unit-1.0 Introduction to Bioinformatics** 1.1 Computers in Biology and Medicine, Information Chaos, 1.2 Challenges in the postgenomic era 1.3 Database concept, protein and nucleic acid databases, specialised genome databases (HGD, MGD, SGD, TIGR, and ACeDB). 1.4 Structural databases, Gene databases, Protein databases 1.5 Searching databases, The NCBI: Publicly available tools 1.6 Resources at EBI, Resources on the web 1.7 Database mining tools, Alphafold.	**CO1**
TSO 2a. Identify different types of proteins based on their structure and function. *TSO 2b.* Describe the relationship between amino acid sequences and the resulting protein structures and functions. *TSO 2c.* Explain the implications of Anfinsen's dogma on protein folding and stability. *TSO 2d.* Use case studies to illustrate specific challenges encountered in protein structure research. *TSO 2e.* Utilize visualization tools to demonstrate the 3D structure of a given protein. *TSO 2f.* Explain the timescales of different types of molecular motions in proteins. *TSO 2g.* Evaluate the effectiveness of various methods and tools for studying protein motion.	**Unit-2.0 Protein Folding and Flexibility** 2.1 Diversity in protein function and protein structure 2.2 Link between sequence, structure and function, Misfolding problem, 2.3 Anfinsen's dogma, Lavinthal's paradox, 2.4 Challenges in understanding structure 2.5 Methods for determining 3D structure, Protein databank, Visualisation of macromolecules. 2.6 Dynamic motion in biological processes, Motion and function, Examples 2.7 Types of Molecular Motions, Timescale of protein motion, Methods to study protein motion, Database of macromolecules, Online Servers and Software Tools.	**CO2**
TSO 3a. Illustrate examples of molecular recognition in biological systems. *TSO 3b.* Analyse the differences between the induced fit and lock-and-key models of enzyme activity. *TSO 3c.* Explain the role of solvent effects and hydrophobic interactions in the process of molecular recognition. *TSO 3d.* Analyse the relationship between secondary and tertiary structures and their functional implications in proteins.	**Unit-3.0 Molecular Recognition and Protein Secondary Structures** 3.1 Molecular recognition: Process of recognition, Complementary features upon binding, Tolerance upon binding 3.2 Induced fit theory, Adaptation of enzyme and ligand, Domino effect, 3.3 Ensemble of conformations, Forces involved in recognition, Solvent effect, Hydrophobic effect.	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 3e. Apply knowledge of protein domains to predict the function of a given protein based on its structure.	3.4 Secondary and tertiary structure of proteins: Protein architecture, Conformation, Ramachandran plot, Characteristics of secondary structural elements, Alpha helices, Beta sheet and reverse turns, 3.5 Super secondary structure, Domains, New levels of protein architecture.	
TSO 4a. Classify given protein structures into their respective topological categories using appropriate criteria. *TSO 4b.* Use CATH and SCOP databases to find examples of protein classifications for given sequences. *TSO 4c.* Complete pairwise and multiple sequence alignments using given sequences and appropriate tools. *TSO 4d.* Compare the outputs from different alignment software to evaluate their effectiveness in specific contexts. *TSO 4e.* Explore the computational efficiency and limitations of the Smith-Waterman algorithm compared to global alignment methods.	**Unit-4.0 Protein Folds & Sequence Alignment** 4.1 Classification of protein folds and topology: All alpha topology, All beta topology, Alpha-beta topology, Alpha+beta topology 4.2 Classification of Proteins, CATH, SCOP. 4.3 Sequence Alignment: DNA /protein sequences analysis, Alignment, pairwise and global alignment, multiple alignment, structure-based alignment 4.4 Software tools, BLAST, FASTA, CLUSTAL, Scoring matrices, Algorithms, Needleman-Wunsch 4.5 Smith-Waterman algorithms, Dynamics programming, Molecular Phylogenetics.	**CO4**
TSO 5a. Select appropriate templates for a given protein structure. *TSO 5b.* Implement the Tweak Algorithm for refining a protein model using available online tools. *TSO 5c.* Utilise fold recognition techniques to predict the structure of a GPCR based on its amino acid sequence. *TSO 5d.* Compare different software applications in terms of accuracy, usability, and output quality for 3D structure prediction. *TSO 5e.* Use structure-based drug design techniques to identify potential drug candidates for a specific disease area.	**Unit -5.0: Structure Prediction and Application of Bioinformatics** 5.1 Homology modelling, Template selection, Sequence alignment, Secondary structure prediction methods 5.2 Online servers and software, Protein main chain and side chain modelling, Loop modelling, Tweak Algorithm, Refinement and evaluation of models, 5.3 Structure prediction of GPCRs, Fold recognition methods, Ab initio method for structure prediction 5.4 Software used for 3D structure prediction: Structural genomics and its application. 5.5 Protein history, Proteins and pharmaceutical industries, Disease areas, Complex proteins, Applications, structure-based drug design	**CO5**

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

i. Analyze the comparative effectiveness of Alphafold2 vs. Alphafold3 in predicting membrane protein structures and discuss implications for drug discovery.
ii. How do environmental factors (pH, temperature, ionic strength) influence protein misfolding diseases, and what computational models best predict these interactions?
iii. Investigate the relationship between protein flexibility and enzymatic efficiency using molecular dynamics simulations across different protein families.
iv. Analyze the contribution of water molecules in protein-protein recognition events and their implications for rational drug design.
v. Evaluate the accuracy of different multiple sequence alignment algorithms in detecting remote homology relationships in enzyme superfamilies.
vi. Investigate the application of machine learning approaches in structure-based virtual screening for neglected tropical diseases.

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.

- Search NCBI and EBI databases for a specific protein family, compare structural data quality across sources, and create a comprehensive visualisation report demonstrating proficiency in biological database utilisation.
- Analyse a disease-associated misfolded protein using molecular visualisation tools to correlate sequence variations with structural changes and propose potential therapeutic interventions.
- Select an enzyme-inhibitor complex to compare induced fit versus lock-and-key mechanisms, analyze binding site characteristics, and design a virtual screening strategy for novel inhibitors.
- Collect homologous sequences from different species, perform multiple sequence alignments using various tools, construct phylogenetic trees, and evaluate alignment quality and evolutionary relationships.
- Select a protein with unknown structure, perform homology modeling or ab initio prediction, validate the predicted structure, and discuss potential drug design applications.

b. Seminar Topics:

- Alphafold Revolution: Transforming Structural Biology and Drug Discovery
- Big Data Challenges in Genomics: From Storage to Analysis
- Comparative Analysis of Major Biological Databases: NCBI vs. EBI Resources
- Protein Misfolding Diseases: From Molecular Mechanisms to Therapeutic Strategies
- Molecular Dynamics Simulations: Bridging Timescales in Protein Motion
- Intrinsically Disordered Proteins: Challenging the Structure-Function Paradigm
- Water's Role in Protein Function: Beyond the Hydrophobic Effect
- Hidden Markov Models in Sequence Analysis: Beyond Basic Alignment
- Phylogenomics: Large-scale Evolutionary Analysis Using Genomic Data
- AI in Drug Discovery: Machine Learning Approaches for Lead Optimization
- GPCR Structure-Function Relationships: Implications for Personalized Medicine
- Fragment-based Drug Design: Computational Approaches and Success Stories
- Structural Genomics Initiatives: Lessons Learned and Future Prospects

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

COs	Relevant Unit Number and Title	Marks
CO1	Unit 1.0 Introduction to Bioinformatics	10
CO2	Unit 2.0 Protein Folding and Flexibility	10
CO3	Unit 3.0 Molecular Recognition and Protein Secondary Structures	10
CO4	Unit 4.0 Protein Folds and Sequence Alignment	10
CO5	Unit 5.0 Structure Prediction and Application of Bioinformatics	10
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.	Structure Visualization	PyMOL, ChimeraX, VMD	All
3.	Sequence Analysis	MEGA, BioEdit, Jalview	All
4.	Homology Modeling	SWISS-MODEL, MODELLER, I-TASSER	All
5.	Molecular Docking Software	AutoDock, Vina, FlexX	All
6.	Statistical Tools	SPSS	All

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Bioinformatics- a Practical Guide to the Analysis of Genes and Proteins	Baxevanis, A.D. and Francis Ouellellette, B.F.	Wiley India Pvt Ltd. 2009 ISBN: 978-0471478782
2.	Introduction to bioinformatics	Teresa K. Attwood, David J. Parry-Smith,	Pearson Education. 1999 ISBN 0-582-327-881
3.	Bioinformatics for Dummies	Jean-Michel Claverie, Cedric Notredame.	Publisher: Dummies, Jan 2007 Isbn-13: 978-0-470-08985-9
4.	Bioinformatics: Sequence and Genome Analysis	David W. Mount	Cold Spring Harbor Laboratory Press, ISBN: 978-0879697121
5.	Introduction to Bioinformatics	Arthur M. Lesk	Oxford University Press, ISBN: 978-0199651566
6.	Bioinformatics and Functional Genomics	Jonathan Pevsner	Wiley-Blackwell, ISBN: 978-1118581780

b) Online Educational Resources (OER):

1) NCBI Education: https://www.ncbi.nlm.nih.gov/education/
2) EBI Training: https://www.ebi.ac.uk/training/
3) Bioinformatics.org: http://bioinformatics.org/
4) ExPASy Bioinformatics Resource Portal: https://www.expasy.org/
5) Protein Data Bank: https://www.rcsb.org/

Q) Course Curriculum Developer

S. No.	Name	E-mail Address
1.	Prof. Bashirulla Shaik	bshaik@nitttrbpl.ac.in

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A)	**Course Title:** Molecular Modelling and Drug Design	Deemed to be University under Distinct Category
B)	**Course Code:** MSCBS07	
C)	**Pre- requisite (s):**	

D) **Rationale:** The rapid advancement in computational biology and bioinformatics has revolutionized drug discovery processes, making molecular modeling an indispensable tool in modern pharmaceutical research. This course provides comprehensive training in theoretical foundations and practical applications of molecular modeling techniques specifically tailored for drug design. Students will gain expertise in force field theory, molecular dynamics simulations, and various computational approaches to drug discovery, including structure-based and ligand-based drug design. The curriculum integrates fundamental concepts with hands-on experience using industry-standard software, preparing graduates for careers in pharmaceutical research, biotechnology, and academic research institutions. Given the growing emphasis on precision medicine and personalized therapeutics, this course addresses the critical need for professionals who can bridge computational chemistry and pharmaceutical sciences.

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
MSCBS07.CO1	Analyse molecular systems using force fields and energy minimisation
MSCBS07.CO2	Apply first-order optimisation to identify energy minima.
MSCBS07.CO3	Evaluate structural and thermodynamic biomolecular properties.
MSCBS07.CO4	Assess drug action and stages of drug discovery.
MSCBS07.CO5	Implement structure-based drug design using docking, virtual screening, and de novo methods.

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, specialised, and professional tasks relating to teaching, research and development.	**PO-2** Demonstrate acquiring advanced cognitive and technical skills required for evaluating research findings and designing and conducting research in Biopharmaceutical Science.	**PO-3** Apply advanced knowledge of research methods to conduct research and investigations to formulate evidence-based solutions to complex and unpredictable problems in Biopharmaceutical Science.	**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 Biopharmaceutical Science, by following basic research ethics.
MSCBS07.CO1	3	3	2	1
MSCBS07.CO2	3	3	2	1
MSCBS07.CO3	2	3	3	1
MSCBS07.CO4	2	3	3	2
MSCBS07.CO5	3	3	3	2

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
MSCBS07	PEC	Molecular Modelling and Drug Design	45	15	-	30	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, and 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 Harmonic Oscillator Model and identify its limitations in modeling molecular vibrations. *TSO 1b.* Evaluate scenarios where one potential model is more suitable than the other. *TSO 1c.* Describe the relationship between molecular forces and energies in different molecular systems. *TSO 1d.* Explain the fundamental principles behind each type of potential and their practical significance. *TSO 1e.* Compare the performance and usability of AMBER vs. GROMOS in various research contexts. *TSO 1f.* Implement appropriate force field parameters in molecular modeling problems involving small organic molecules.	**Unit-1.0 Force Field Parameters and Models** 1 1. Introduction to Molecular Modelling and Force Fields: Hooke's Law and its relevance to molecular vibrations, Harmonic Oscillator Model for Molecules, Limitations of Harmonic Oscillator 1 2. Advanced Potential Energy Models: Morse Potential: Introduction and application, Comparison of Morse and Harmonic Potentials 1 3. Molecular Forces and Energies, Intra-molecular forces and energies, Inter-molecular forces and energies 1 4. Interatomic and Intermolecular Potentials: Lennard-Jones, Truncated Lennard-Jones, Exponential-6, Ionic, and Polar Potentials 1 5. Types of Force Fields: Biomolecular Force Fields: AMBER, GROMOS 1 6. Small Organic Molecule Force Fields: MM series (e.g., MM2, MM3, MM4), Second Generation Force Fields: UFF (Universal Force Field), CFF (Consistent Force Field), MMFF (Merck Molecular Force Field)	**CO1**
TSO 2a. Explain the significance of convergence criteria in optimisation. *TSO 2b.* Identify stationary points on a PES, distinguishing between minima, maxima, and saddle points. *TSO 2c.* Describe multivariable minimisation algorithms *TSO 2d.* Explain the importance of gradients in optimisation. *TSO 2e.* Explain the limitations of the unidirectional search method. *TSO 2f.* Implement a defined strategy to successfully find minimum points within a given function or dataset. *TSO 2g.* Explain the fundamental principles behind the Steepest Descent and Conjugate Gradient methods. *TSO 2h.* Analyse the comparative effectiveness of the Steepest Descent and Conjugate Gradient methods on various optimisation problems.	**Unit-2.0 Potential Energy Surface (PES) and Energy Minimisation** 2.1 Potential Energy Surface (PES), Definition and features of PES, Convergence criteria for optimisation, Characterisation of stationary points on PES (minima, maxima, saddle points) 2.2 Energy Minimisation Concepts, Multivariable minimisation algorithms, Level sets and energy contours, Gradients and their role in optimisation, Criteria for minimisation convergence 2.3 Minimisation Techniques, Unidirectional Search: Basic approach and limitations, Strategies to find the minimum points, 2.4 First-Order Optimisation Methods: Steepest Descent, Conjugate Gradient Method	**CO2**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 3a. Describe the principles of molecular dynamics simulations and the significance of Newtonian dynamics in modeling particle motion. *TSO 3b.* Compare the Verlet and Leapfrog algorithms in terms of their applications and stability in numerical integration. *TSO 3c.* Calculate RDF and PCF for given simulation data to interpret the structure of the molecular system. *TSO 3d.* Explain the effects of potential truncation techniques on simulation accuracy and computational efficiency. *TSO 3e.* Differentiate between explicit and implicit solvation models and their respective advantages and disadvantages. *TSO 3f.* Describe the role of periodic boundary conditions and their impact on the simulation of bulk properties. *TSO 3g.* Analyze the impact of different boundary conditions on simulation results, particularly in systems exhibiting phase transitions	**Unit-3.0 Molecular Dynamics Simulations** 3.1 Fundamentals of Molecular Dynamics: Introduction to Molecular Dynamics Simulations, Newtonian Dynamics: Equations of motion for particles 3.2 Numerical Integration Algorithms: Verlet Algorithm, Leapfrog Algorithm 3.3 System Analysis in MD: Radial Distribution Functions (RDF), Pair Correlation Functions (PCF) 3.4 Force and Potential Modifications: Potential Truncation Techniques, Shifted-Force Potentials 3.5 Solvation and Simulation Models, Solvation Models: Explicit vs. Implicit, Modeling solvent effects in MD 3.6 Simulation Conditions and Boundary Settings: Periodic Boundary Conditions (PBC), Temperature Control Methods (e.g., thermostats), Pressure Control Methods (e.g., barostats)	**CO3**
TSO 4a. Describe effects of each component of ADME on drug action and therapeutic outcomes. *TSO 4b.* Explain the mechanisms of drugs interact with receptors to elicit therapeutic and toxic effects. *TSO 4c.* Use dose-response curves to determine the therapeutic index of drugs from given data. *TSO 4d.* Describe the processes involved in target identification and validation. *TSO 4e.* Explain experimental and computational methods used for validating molecular targets in drug discovery. *TSO 4f.* Explain the significance of Structure-Activity Relationship (SAR) studies in drug development. *TSO 4g.* Implement a structure-activity relationship analysis for a given	**Unit-4.0 Basis of Drug Action:** 4.1 Fundamentals of Drug Action: Pharmacokinetics (ADME): Absorption, Distribution, Metabolism, Excretion 4.2 Pharmacodynamics: Drug-receptor interactions, Dose-response relationships, Therapeutic and toxic effects 4.3 Drug Discovery Process: Target Identification and Validation: Molecular targets (enzymes, receptors, pathways), Experimental and computational methods of validation 4.4 Lead Identification and Optimisation: High-throughput screening, virtual screening, Structure-activity relationship (SAR) studies, Optimisation for potency, selectivity, and ADME properties 4.5 Drug Development and Testing: Pre-clinical Testing: In vitro and in vivo studies, Toxicity, pharmacokinetics, efficacy assessments	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
compound to determine its optimization potential. *TSO 4h.* Differentiate between in vitro and in vivo studies in the context of drug testing. *TSO 4i.* Describe the objectives and methodologies used in each phase of clinical trials. *TSO 4j.* Assess case studies of clinical trial outcomes to evaluate the safety and efficacy of marketed drugs.	4.6 Clinical Trials: Phase I: Safety and dosage, Phase II: Efficacy and side effects, Phase III: Large-scale testing and comparison, Phase IV: Post-marketing surveillance	
TSO 5a. Explain the steps involved in sequence alignment, template selection, and model refinement. *TSO 5b.* Assess the reliability of a protein model based on validation results. *TSO 5c.* Describe the basic principles underlying docking procedures and their significance in drug design. *TSO 5d.* Analyze the results of docking studies to distinguish between effective and ineffective leads. *TSO 5e.* Examine the strengths and weaknesses of different de novo design techniques. *TSO 5f.* Explain the principles and applications of hybrid approaches in virtual screening. *TSO 5g.* Analyze the effectiveness of different virtual screening strategies in lead identification. *TSO 5h.* Describe methods for 3D database searching and conformation generation. *TSO 5i.* Execute pharmacophore-based virtual screening for lead optimization. *TSO 5j.* Prepare datasets and calculate descriptors for QSAR analysis. *TSO 5k.* Differentiate between various types of descriptors and their applications in QSAR. *TSO 5l.* Describe the significance of Partial Least Squares (PLS) in model building.	**Unit -5.0: Drug Design Approaches: - Structure-Based Drug Design** 5.1 Protein Structure Prediction and Validation: Homology Modelling for Docking: Sequence alignment and template selection, Model building and refinement, Validation of 3D protein structure (e.g., Ramachandran plot, energy checks) 5.2 Molecular Docking: Basis of Docking, Pose prediction algorithms, Scoring functions (energy-based, empirical, knowledge-based), Applications of Docking, Lead identification, Lead optimization 5.3 De Novo Drug Design: Design Approaches: Fragment Placement Methods, Connection Methods, Sequential Growth Techniques 5.4 Virtual Screening for Lead Identification, Virtual Screening Strategies, Structure-based virtual screening, Ligand-based virtual screening, Hybrid approaches 5.5 Ligand-Based Drug Design: Pharmacophore Generation and Use: 3D database searching, Conformation generation and searches, Deriving 3D pharmacophores, Methods: Constrained systematic search, Genetic algorithm, Clique detection techniques, Maximum likelihood method 5.6 Applications: Pharmacophore-based virtual screening, Scaffold hopping and optimisation.	**CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 5m. Explain the concept of statistical significance in the context of QSAR models. *TSO 5n.* Evaluate the robustness of models based on validation results and statistical metrics. *TSO 5o.* Utilise QSAR models to predict biological activity and toxicity of new compounds.	5.7 Quantitative Structure-Activity Relationship (QSAR): QSAR Fundamentals, Types of Descriptors (physicochemical, topological, electronic, etc.), Dataset preparation and descriptor calculation 5.8 Model Building Methods: Regression Analysis, Principal Component Analysis (PCA), Partial Least Squares (PLS) 5.9 Model Validation Techniques: Cross-validation, External test sets, Statistical significance (r^2, q^2, RMSE) 5.10 Applications of QSAR: Activity prediction, Toxicity prediction, Optimisation of lead compounds	

J) Suggested Laboratory experiences: (Not Applicable)

K) Suggested Research Based Problems

i. Conduct a comparative force field analysis to evaluate the performance of AMBER and GROMOS in predicting protein-ligand binding conformations for a specific target family.
ii. Perform a molecular dynamics study to analyse conformational changes in HIV protease due to mutations and assess their impact on drug binding affinity.
iii. Design and validate a virtual screening pipeline for identifying novel inhibitors against a defined therapeutic target using integrated computational approaches.
iv. Develop predictive QSAR models for blood-brain barrier permeability using machine learning techniques and innovative molecular descriptors.
v. Apply fragment-based de novo drug design methods to generate novel scaffolds aimed at targeting allosteric sites in protein kinases.
vi. Utilise pharmacophore modelling to optimise lead compounds with a focus on enhancing selectivity and minimising toxicity.

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.

- Assign suitable force field parameters to a novel small molecule and validate them through energy minimisation studies.

- Develop and execute a complete molecular dynamics simulation protocol for a protein-ligand complex, including system setup, equilibration, and production phases.
- Conduct virtual screening of compound libraries against a selected biological target and evaluate hit compounds based on multiple selection criteria.
- Construct and validate QSAR models for bioactive compounds using various statistical and machine learning techniques.
- Compare binding poses of known inhibitors to their target protein using different docking algorithms and scoring functions.
- Evaluate how different solvation models influence the predicted binding affinity in drug-target interactions.
- Analyze correlations between molecular descriptors and biological activity for compounds with established structure-activity relationship (SAR) data.

b. Seminar Topics:

- Recent Advances in AI-Driven Drug Discovery: Applications of machine learning and deep learning in pharmaceutical research.
- Challenges in Fragment-Based Drug Design: Current methodologies and success stories in fragment-based approaches.
- Molecular Dynamics in Drug Design: Case studies of successful MD applications in lead optimization.
- Free Energy Perturbation Methods: Theory and applications in predicting binding affinities.
- Covalent Drug Design: Computational approaches for designing covalent inhibitors.

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 Force field parameters and models	10
CO2	Unit 2.0 Potential Energy Surface (PES) and Energy Minimisation	8
CO3	Unit 3.0 Molecular dynamics Simulations	10
CO4	Unit 4.0 Basis of Drug Action	10
CO5	Unit 5.0 Drug Design Approaches: - Structure-Based Drug Design	12
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), Moistest 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.	Biovia Discovery Studio	S/w to be downloaded for python 3.11.3 or higher	All

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Computational Chemistry and Molecular Modeling-Principles and Applications	Ramachandran, Deepa and Namboori.	2008, Springer-Verlag.
2.	Molecular Modeling Principles and Applications (2nd Ed.)	Andrew R. Leach., Prentice Hall	, USA. 2001
3.	Computational Drug Design: A Guide for Computational and Medicinal Chemists,	David C. Young,	Wiley, 2009
4.	Molecular Modelling for Beginners, (2nd Edition)	Alan Hinchliffe., John Wiley Sons	Ltd.2008
5.	Computational Medicinal Chemistry for Drug Discovery	Patrick Bultinck., Hans De Winter, Wilfried Langenaeker, Jan P. Tollenare,	CRC press, 2003
6.	The art of molecular dynamics simulation, second edition	D. C. Rapaport,	Cambridge University Press, 2004
7.	Homology Modelling Methods and Protocols	Andrew J.W. Orry	University of California, USA.2012.

b) Online Educational Resources (OER):

1) National Centre for Biotechnology Information (NCBI): https://www.ncbi.nlm.nih.gov/
2) European Molecular Biology Laboratory (EMBL-EBI): https://www.ebi.ac.uk/
3) Drug Discovery Today: https://www.drugdiscoverytoday.com/
4) Journal of Computer-Aided Molecular Design: https://link.springer.com/journal/10822

5) Computational and Structural Biotechnology Journal: https://www.sciencedirect.com/journal/computational-and-structural-biotechnology-journal

c) MOOCs (SWAYAM Links):

6) Computational Biology" - https://swayam.gov.in/nd1_noc20_bt08
7) "Bioinformatics: Algorithms and Applications" - https://swayam.gov.in/nd1_noc19_bt07
8) "Introduction to Molecular Dynamics Simulations" - https://swayam.gov.in/nd1_noc20_ch12

d) YouTube Video Resources:

9) Molecular Dynamics Simulations Basics
10) Introduction to Drug Design
11) PyMOL Tutorial Series
12) GROMACS Tutorial
13) Protein-Ligand Docking Tutorial

Q) Course Curriculum Developer

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A)	**Course Title:** Formulation Strategies and Pharmacokinetics	Deemed to be University under Distinct Category
B)	**Course Code:** MSCBS08	
C)	**Pre- requisite (s):**	

D) **Rationale:** This course provides comprehensive knowledge of biopharmaceutical formulation development, manufacturing processes, and pharmacokinetic principles essential for developing safe and effective biological therapeutics. Students will gain expertise in formulation strategies for biologics, including protein formulations, novel delivery systems, and manufacturing considerations. Integrating pharmacokinetic and pharmacodynamic principles enables understanding of drug behavior in biological systems, which is essential for rational drug development and optimisation of therapeutic outcomes in biopharmaceutical industries.

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

Course Outcomes (COs)	Course Outcome Statements
MSCBS08.CO1	Address formulation challenges and develop strategies for biologics.
MSCBS08.CO2	Assess manufacturing, quality control, and regulatory needs.
MSCBS08.CO3	Apply PK/PD concepts to optimise dosing and outcomes.
MSCBS08.CO4	Design and evaluate novel drug delivery systems
MSCBS08.CO5	Use regulatory knowledge and tools to solve formulation issues.

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, specialised, and professional tasks relating to teaching, research and development.	**PO-2** Demonstrate acquiring advanced cognitive and technical skills required for evaluating research findings and designing and conducting research in Biopharmaceutical Science.	**PO-3** Apply advanced knowledge of research methods to conduct research and investigations to formulate evidence-based solutions to complex and unpredictable problems in Biopharmaceutical Science.	**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 Biopharmaceutical Science, by following basic research ethics.
MSCBS08.CO1	3	2	3	2
MSCBS08.CO2	2	3	3	2
MSCBS08.CO3	2	3	3	1
MSCBS08.CO4	3	3	3	2
MSCBS08.CO5	2	3	3	2

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
MSCBS08	PEC	Formulation Strategies and Pharmacokinetics	45	15	-	30	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, and renewable energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Describe the significance of Quality by Design (QbD) principles in biopharmaceutical development. *TSO 1b.* Explain the principles of bioprocess development and manufacturing *TSO 1c.* Explain the formulation challenges, such as stability, aggregation, and denaturation. *TSO 1d.* Implement a preformulation study for a specific biologic. *TSO 1e.* Differentiate between various analytical approaches for assessing biologics. *TSO 1f.* Biotherapeutics Drug Product Development *TSO 1g.* Conduct dosage form development for a selected biologic and justify your choices. *TSO 1h.* Investigate potential interactions between biologics and packaging materials.	**Unit-1.0 Biopharmaceutical Fundamentals and Formulation Development** 1.1 Bioprocess fundamentals: upstream and downstream processing, Introduction to bioanalytics and bioassays, Quality by Design (QbD) principles in biopharmaceuticals 1.2 Introduction to Formulation Development of Biologics: Characteristics of biological molecules (proteins, antibodies, vaccines), Formulation challenges: stability, aggregation, denaturation, 1.3 Preformulation studies and characterisation techniques, 1.4 Analytical methods for biologics characterisation, Regulatory guidelines for biologics formulation 1.5 Biotherapeutics Drug Product Development: Drug product design considerations, Route of administration selection, Dosage form development for biologics, Stability studies and accelerated testing 1.6 Compatibility studies with packaging materials, Regulatory submissions and documentation	**CO1**
TSO 2a. Demonstrate the application of cGMP practices in a hypothetical manufacturing scenario. *TSO 2b.* Apply process validation techniques to a case study of biologics manufacturing. *TSO 2c.* Illustrate the steps of contamination control strategies that can be implemented in a manufacturing facility. *TSO 2d.* Differentiate between various excipient regulatory considerations across jurisdictions. *TSO 2e.* Investigate the causes and mitigation approaches for injection site reactions. *TSO 2f.* Analyze data from various analytical methods to determine formulation stability.	**Unit-2.0 Manufacturing, Processing, and Quality Considerations** 2.1 Manufacturing and Process Development: cGMP requirements for biologics manufacturing 2.2 Process development and scale-up considerations, Critical process parameters and control strategies, Process validation and qualification, Technology transfer and manufacturing readiness 2.3 Facility Considerations and Infrastructure: Facility design and layout for biologics manufacturing, Cleanroom classification and environmental monitoring, Utilities and support systems, Equipment qualification and validation, Contamination control strategies, Personnel training and qualification 2.4 Excipients for biologics: buffers, stabilisers, surfactants, preservatives, Excipient qualification and regulatory considerations	**CO2**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
	2.5 High concentration protein formulation challenges, Viscosity reduction strategies, Injection site reactions and mitigation approaches. 2.6 Analytical challenges for high concentration formulations	
TSO 3a. Explain the mechanisms of cryoprotectants and their importance in preserving biologics during freeze-thaw cycles. *TSO 3b.* Analyze temperature excursion data to determine its effects on product stability. *TSO 3c.* Analyze compatibility testing results to evaluate the suitability of primary packaging materials. *TSO 3d.* Summarize the formulation considerations necessary for effective lyophilisation. *TSO 3e.* Compare different delivery routes, including implantable and injectable depot systems, for their efficacy. *TSO 3f.* Analyze case studies to identify successful and unsuccessful formulation approaches.	**Unit-3.0 Advanced Formulation Strategies and Novel Delivery Systems** 3.1 Freeze-Thaw Processes and Storage Considerations: Freeze-thaw stress on biologics, Cryoprotectants and their mechanisms, Storage condition optimisation 3.2 Cold chain management and shipping considerations, Temperature excursion studies, Real-time stability monitoring 3.3 Container Closure Systems and Extractables/Leachables: Container closure system selection criteria, Primary packaging materials for biologics, Extractables and leachables studies, Risk assessment and mitigation strategies, Regulatory requirements for packaging systems, Compatibility testing protocols 3.4 Principles of lyophilisation for biologics, Formulation considerations for lyophilisation, Process design and optimisation, Critical process parameters and monitoring, Risk assessment and mitigation strategies, Robustness testing and validation 3.5 Sustained release formulations for biologics, Targeted drug delivery systems, Nanoparticle-based delivery systems, Implantable and injectable depot systems, Transdermal and alternative delivery routes 3.6 Formulation case studies and applications	**CO3**
TSO 4a. Explain the key absorption mechanisms and barriers affecting biologics. *TSO 4b.* Summarise the fundamental principles of pharmacokinetic modelling and its significance in drug development. *TSO 4c.* Dissect the interactions between biologics and their targets at the molecular level.	**Unit-4.0 Pharmacokinetic and Pharmacodynamic Principles** 4.1 Routes of administration for biologics, Absorption mechanisms and barriers, Distribution patterns and tissue penetration 4.2 Biotransformation and elimination pathways, Pharmacokinetic modeling and simulation, Bioavailability and bioequivalence concepts	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 4d. Explain the significance of dose-response relationships in pharmacotherapy. *TSO 4e.* Illustrate a case where PK-PD modeling is applied to predict therapeutic outcomes in biologics. *TSO 4f.* Examine case studies illustrating the successful application of biomarkers in biologic therapies.	4.3 Principles of drug action for biologics, Mechanism of action and target engagement, Receptor theory and binding kinetics 4.4 Dose-response relationships, Drug efficacy, potency, and therapeutic index, LD50, ED50, and safety margins, Synergism, antagonism, and drug interactions, Factors modifying drug action 4.5 PK-PD characteristics of biologics, Immunogenicity and its impact on PK-PD, PK-PD modeling for biologics 4.6 Biomarker strategies and surrogate endpoints, Exposure-response relationships, Population PK-PD approaches, Case studies in biologics PK-PD	
TSO 5a. Explain the importance of dosage form selection and optimization in drug development. *TSO 5b.* Explain pharmacovigilance processes and requirements *TSO 5c.* Use pharmacogenomic data to support clinical decision-making for individualized therapy. *TSO 5d.* Describe the roles of companion diagnostics and theranostics in personalized treatment plans. *TSO 5e.* Investigate case studies on the implementation of precision dosing in clinical practice.	**Unit-5.0 Clinical Applications and Regulatory Considerations** 5.1 Clinical trial design for biologics, Dosage form selection and optimisation, Pharmacokinetic calculations and dosing algorithms, Pharmacoeconomics and cost-effectiveness analysis, Health technology assessment, Market access considerations 5.2 Types and mechanisms of adverse drug reactions, Pharmacovigilance systems and reporting, Risk management plans and mitigation strategies, Signal detection and evaluation, Benefit-risk assessment, Regulatory requirements for safety monitoring 5.3 Pharmacogenomic principles and applications, Biomarker discovery and validation 5.4 Personalised medicine approaches for biologics, Companion diagnostics and theranostics 5.5 Precision dosing strategies, Regulatory considerations for personalised medicine	**CO5**

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

i. Formulation Optimization Study: Design and optimize a high-concentration monoclonal antibody formulation (>100 mg/mL) addressing viscosity, stability, and injectability challenges.
ii. Lyophilisation Process Development: Develop a robust lyophilisation process for a temperature-sensitive protein therapeutic, including formulation design, process optimisation, and risk assessment.
iii. Novel Delivery System Design: Create a sustained-release formulation for a peptide hormone using biodegradable microspheres, including in vitro characterization and release kinetics.
iv. PK-PD Modeling Project: Develop a population pharmacokinetic model for a therapeutic antibody in a specific patient population, incorporating immunogenicity effects.
v. Container Closure Compatibility Study: Conduct comprehensive extractables and leachables studies for a novel container closure system intended for biologic storage.
vi. Cold Chain Optimization: Design and validate a temperature-controlled shipping protocol for a freeze-sensitive biologic, including risk assessment and mitigation strategies.

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) SuggestedTerm Work (TW):

a) Assignment(s):

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

- Conduct a comparative analysis of formulation strategies used for monoclonal antibodies, vaccines, and gene therapies.
- Write a critical review of key regulatory guidelines (ICH Q5C, Q6B, FDA) relevant to biologics formulation development.
- Analyze a case study of a failed biopharmaceutical product to identify key formulation or regulatory lessons learned.
- Design a comprehensive quality control strategy for a complex biologic formulation, addressing critical quality attributes.

b) Seminar Topics:

- Emerging trends in biologic drug delivery systems
- Artificial intelligence applications in formulation development
- Regulatory landscape for biosimilars and interchangeable products
- Sustainable practices in biopharmaceutical manufacturing
- Challenges and opportunities in pediatric biologic formulations
- Pharmacovigilance in the era of personalised biologics

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

COs	Relevant Unit Number and Title	Marks
CO1	Unit 1.0Biopharmaceutical Fundamentals and Formulation Development	10
CO2	Unit 2.0Manufacturing, Processing, and Quality Considerations	10
CO3	Unit 3.0Advanced Formulation Strategies and Novel Delivery Systems	10
CO4	Unit 4.0Pharmacokinetic and Pharmacodynamic Principles	10
CO5	Unit 5.0 Applications and Regulatory Considerations	10
Total		**50**

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: (Not Applicable)

P) Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Formulation and Process Development Strategies for Manufacturing Biopharmaceuticals	Jameel, F. and Hershenson, S.	John Wiley & Sons ISBN: 978-0-470-11718-5
2.	Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications	Crommelin, D.J.A., Sindelar, R.D., and Meibohm, B.	Springer, ISBN: 978-1-4614-6486-0
3.	Pharmacokinetics and Pharmacodynamics of Biotech Drugs	Meibohm, B.	Wiley-VCH ISBN: 978-3-527-31408-9
4.	Protein Formulation and Delivery	McNally, E.J. and Hastedt, J.E.	CRC Press, ISBN: 978-1-4200-4319-6

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
5.	Biopharmaceutics and Clinical Pharmacokinetics	Notari, R.E., Marcel Dekker	ISBN: 978-0-8247-8545-4
6.	Handbook of Pharmaceutical Biotechnology	Gad, S.C.	John Wiley & Sons, ISBN: 978-0-471-21545-8
7.	Pharmaceutical Manufacturing Handbook: Production and Processes.	Gad, S.C.	ISBN: 978-0-471-25959-0
8.	Stability of Protein Pharmaceuticals	Ahern, T.J. and Manning, M.C.	Plenum Press ISBN: 978-0-306-44273-4
9.	Parenteral Medications	Trissel, L. A	American Society of Health-System Pharmacists, ISBN: 978-1-58528-423-4
10.	Goodman & Gilman's The Pharmacological Basis of Therapeutics	Brunton, L.L.	McGraw-Hill, ISBN: 978-0-07-162442-8

b) Online Educational Resources (OER):

1) FDA Guidance Documents:https://www.fda.gov/drugs/guidance-compliance-regulatory-information/guidances-drugs
2) ICH Guidelines:https://www.ich.org/products/guidelines.html
3) PharmaCircle:https://www.pharmacircle.com/ (Industry intelligence and regulatory updates)
4) BioPharma Dive:https://www.biopharmadive.com/ (Industry news and analysis)
5) European Medicines Agency (EMA):https://www.ema.europa.eu/en (Regulatory guidelines)

Q) Course Curriculum Developer

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A)	**Course Title:** Project
B)	**Course Code:** PD01
C)	**Pre- requisite (s):**

Deemed to be University under Distinct Category

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

2. Teaching & Learning and Assessment Scheme:

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

3. Broad guidelines for major project work

- The project's problems/themes/ should be relevant to current issues and practices of the industry/society.
- The project should address the majority of the outcomes at the programme level.
- Provision for self-assessment, assessment by teacher/expert should be incorporated to improve the quality of the project work and ensure a higher level of learning aligned to programme level outcomes.
- Provision to showcase a learning portfolio as a project output.

- The learners should be encouraged to publish the work (in the form of a paper, newspaper item, case study, report, etc.) after getting approval from the guide and the organization where the project is completed.
- The learners should submit the plagiarism check report during the final submission.
- Learners should record the output/ periodic achievements of significant interactions, feedback, discussions, and events at different milestones using a logbook.
- The schedule for project work is mentioned in table 1.
- The learners will be assessed during different stages of the project as per the rubrics mentioned in table 2.
- The project proposal and the report are to be prepared as per format 1 and format 2, respectively.

Table-1

4. Schedule of the Project work

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

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

Format 1

Project Proposal

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

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

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

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

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

Table 2

5. Assessment Rubrics for Project Work

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

S. No.	Criterion	Very Good (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
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 formal, consistent,	Language is generally clear and appropriate. Style is mostly formal and consistent. The quality of the	Language is understandable, but is informal. Style occasionally deviates from the formal standards. The	Language is unclear, informal, or inappropriate for a technical report. Style is inconsistent and

S. No.	Criterion	Very Good (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
		and well-suited, hence enhancing the overall quality of the report.	report is acceptable.	quality of the report is moderate	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 effectively. Excellent use of visuals (e.g.,	Slides are well-structured. Content is mostly relevant and supports the spoken presentation. Visuals are used appropriately. Minor issues in font	Slides have a basic structure but are cluttered. Lack proper visual support. Too much of text. Font size and colour is not appealing.	Slides are poorly designed or difficult to read. Content is disorganized, excessive, or irrelevant. Visuals are missing or irrelevant. Font size and colour are poor.

S. No.	Criterion	Very Good (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
		graphs, images, icons). Fonts, size, colours, and layout enhance readability.	size, colour, and layout.		
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
1.	Prof. Sanjay Agrawal	sagrawal@nitttrbpl.ac.in
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Course Curriculum Detailing- Online Spell -1

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

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

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

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

F) Suggested Course Articulation Matrix (CAM):

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

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

G) Teaching & Learning and Assessment Scheme:

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

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

I) Theory Session Outcomes (TSOs) and Units:

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

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.

vii. 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

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

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

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

L) Suggested Term Work (TW):

a. Assignment(s):

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

b. Seminar Topics:

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

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

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

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. Some of them are improved lecture, tutorial, case method, group discussion, industrial visits, industrial training, field trips, portfolio based, learning, role play, live demonstrations in classrooms, lab, field information and communications technology (ICT)based teaching learning, blended or flipped mode, brainstorming, expert session, video clippings, use of open educational resources (OER), MOOCs etc. To ensure learning, research-based problems may be designed and implemented.

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

P) Suggested Learning Resources:

a) Books

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

b) Online Educational Resources (OER):

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

Q) Course Curriculum Development Team

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

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

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

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

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

F) Suggested Course Articulation Matrix (CAM):

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

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

G) Teaching & Learning and Assessment Scheme:

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

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

I) Theory Session Outcomes (TSOs) and Units:

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

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

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

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

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

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

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

L) Suggested Term Work (TW):

a. Assignment(s):

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

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

b. Seminar Topics:

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

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

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

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. Some of them are improved lecture, tutorial, case method, group discussion, industrial visits, industrial training, field trips, portfolio based, learning, role play, live demonstrations in classrooms, lab, field information and communications technology (ICT)based teaching learning, blended or flipped mode, brainstorming, expert session, video clippings, use of open educational resources (OER), MOOCs etc. To ensure learning, research-based problems may be designed and implemented.

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

P) Suggested Learning Resources:

a) Books

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

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

b) Online Educational Resources (OER):

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

Q) Course Curriculum Development Team

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

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

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

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

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

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

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

G) Teaching & Learning and Assessment Scheme:

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

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

I) Theory Session Outcomes (TSOs) and Units:

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

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

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems:

a. Relevance of Ayurveda in Modern Healthcare

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

b. Vedic Astronomy and Modern Astrophysics: A Comparative Study

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

c. Yoga and Mental Health: A Scientific Perspective

- Problem: How can the practice of Yoga and its underlying philosophical principles contribute to mental health therapies in modern psychology?

- Focus: Exploring the psychological benefits of yogic practices like meditation, pranayama, and asanas, and scientifically evaluating their impact on anxiety, depression, and stress management.

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

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

e. Vedic Mathematics and Its Role in Contemporary Education

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

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

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

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

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

h. Ancient Indian Contributions to Astronomy and Navigation

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

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

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

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

L) Suggested Term Work (TW):

a. Assignment(s):

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

i. Comparative Study of Ayurveda and Modern Medicine

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

ii. Contributions of Ancient Indian Mathematicians

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

iii. Analysis of Vedic Astronomy and Its Accuracy

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

iv. Traditional Water Management Systems in India

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

v. Impact of Yoga on Mental and Physical Health

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

vi. Sustainable Agriculture Practices in Ancient India

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

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

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

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

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

ix. Indian Metallurgy: Ancient Innovations and Modern Applications

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

b. Seminar Topics:

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

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

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. Some of them are improved lecture, tutorial, case method, group discussion, industrial visits, industrial training, field trips, portfolio based, learning, role play, live demonstrations in classrooms, lab, field information and communications technology (ICT)based teaching learning, blended or flipped mode, brainstorming, expert session, video clippings, use of open educational resources (OER), MOOCs etc. To ensure learning, research-based problems may be designed and implemented.

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

P) Suggested Learning Resources:

a) Books

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

b) Online Educational Resources (OER):

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

Q) Course Curriculum Developer

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Course Curriculum Detailing- Online Spell -2

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

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

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

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

F) Suggested Course Articulation Matrix (CAM):

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

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

G) Teaching & Learning and Assessment Scheme:

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

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

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Explain the evolution, characteristics, and types of MOOCs. *TSO 1b.* Interpret learner demographics, motivations, and challenges in MOOC environments. *TSO 1c.* Apply instructional design framework and models for MOOC development. *TSO 1d.* Formulate MOOC outcomes. *TSO 1e.* Design the MOOC course structure.	**Unit-1.0 Foundation of MOOC Design** 1.1 History and evolution of MOOCs. 1.2 MOOCs types and their characteristics. 1.3 Role of learning theories in MOOC design. 1.4 Learner psychology in massive open environments. 1.5 Instructional design frameworks and Models – ADDIE, SAM, Advance Organizer. 1.6 MOOC Components. 1.7 Formulating MOOC outcomes. 1.8 Content structuring and organisation	**CO1**
TSO 2a. Explain the philosophy of self-learning material development. *TSO 2b.* Integrate principles of microlearning and media design for content creation. *TSO 2c.* Integrate elements of Dale's Cone of Experience and principles of micro-learning in the development of lessons. *TSO 2d.* Prepare a bank of OER to be integrated into the MOOC. *TSO 2e.* Prepare a lesson/s along with assessment questions and discussion forum statement as per the given guideline	**Unit-2.0 E-Content Lesson Development** 2.1 Philosophy for the development of self-learning material. 2.2 Principles of microlearning and Media design. 2.3 Dale's cone of experience. 2.4 Intellectual Property rights, OER and Creative Commons licenses. 2.5 Designing MCQ and Discussion forum. 2.6 Rubrics for ''Prepare a sample prototype E Content'' 2.7 Sample format/s for the development of lessons mentioned in the course structure.	**CO2**
TSO 3a. Design graphics, animation, presentation and interactive content using media design principles. *TSO 3b.* Create a sample podcast for MOOC. *TSO 3c.* Write a sample video script for the selected MOOC lesson. *TSO 3d.* Write a shooting script. *TSO 3e.* Plan for video production. *TSO 3f.* Present to camera in studio. *TSO 3g.* Edit the video and sound file for finalisation of the sample video.	**Unit-3.0 Digital Media Production** 3.1 Video production pipeline – Video production vocabulary. 3.2 Multi-camera studio production. 3.3 Podcast creation. 3.4 Video script development. 3.5 Graphics design and animation. 3.6 Shooting script development. 3.7 Interactive content creation tools. 3.8 Audio and video editing.	**CO3**
TSO 4a. Describe features of the SWAYAM MOOCs. *TSO 4b.* Design the course structure on ePrashikshan.	**Unit-4.0 MOOC Course Configuration on LMS and its Guidelines** 4.1 SWAYAM Guidelines for MOOC development.	**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.	4.2 Overview of SWAYAM MOOC structure. 4.3 LMS (ePrashikshan) and its features for MOOC 4.4 LMS-specific guidelines for video duration, file formats, accessibility standards, copyright policies, and assessment requirements 4.5 LMS structure design aspects aligned to course structure (course builder) 4.6 Steps for uploading the MOOC component on LMS 4.7 Steps for publishing MOOC content 4.8 Pre-launch Checklist for LMS - Test all links and embedded media, Review course flow from a learner's perspective, Check quiz functionality and grading settings, test for cross-device and browser compatibility 4.9 Pilot and beta testing	

J) Suggested Laboratory Experiences: (Not Applicable)

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

i. Prepare a review paper based on the latest research on the theme related to MOOC design/ delivery/ Assessment of Effectiveness of content/ Effectiveness of activities.

ii. Compare the MOOC course structure of various MOOCs offered on different platforms and present.

iii. Compare different video formats used in various MOOCs offered on different platforms and present.

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

L) Suggested Term Work (TW):

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

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

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

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

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

N) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately used in online and offline mode, as per the requirement of the outcome to be achieved. Some of them are improved lecture, tutorial, case method, group discussion, industrial visits, industrial training, field trips, portfolio based, learning, role play, live demonstrations in classrooms, lab, field information and communications technology (ICT)based teaching learning, blended or flipped mode, brainstorming, expert session, video clippings, use of open educational resources (OER), MOOCs etc. To ensure learning, research-based problems may be designed and implemented.

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

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

P) Suggested Learning Resources:

a) Books

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

b) Online Educational Resources (OER):

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

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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.	**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	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 4e. Analyze how AI can enhance effectiveness of instructional sessions. *TSO 4f.* Evaluate AI-powered personalized learning systems and their effectiveness.	Systems: Intelligent Tutoring Systems, 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
1.	Prof. Susan S. Mathew	ssmathew@nitttrbpl.ac.in
2.	Prof. Chanchal Mehra	cmehra@nitttrbpl.ac.in

******

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 Te chnology.	**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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15. Annexure

15.1 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)

Deemed to be University under
Distinct Category

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(Deemed to be University under Distinct Category)

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Madhya Pradesh, India

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