Curriculum

M.Tech
Computer Science and Engineering
(Big Data Analytics)

July, 2025

School of
Engineering and Technology

Department of
Computer Science and Engineering
Education

Deemed to be University under Distinct Category

NATIONAL INSTITUTE OF TECHNICAL TEACHERS' TRAINING AND RESEARCH (NITTTR), BHOPAL
(Deemed to be University under Distinct Category)
Ministry of Education, Government of India
Shamla Hills, Bhopal – 462 002
Madhya Pradesh, India

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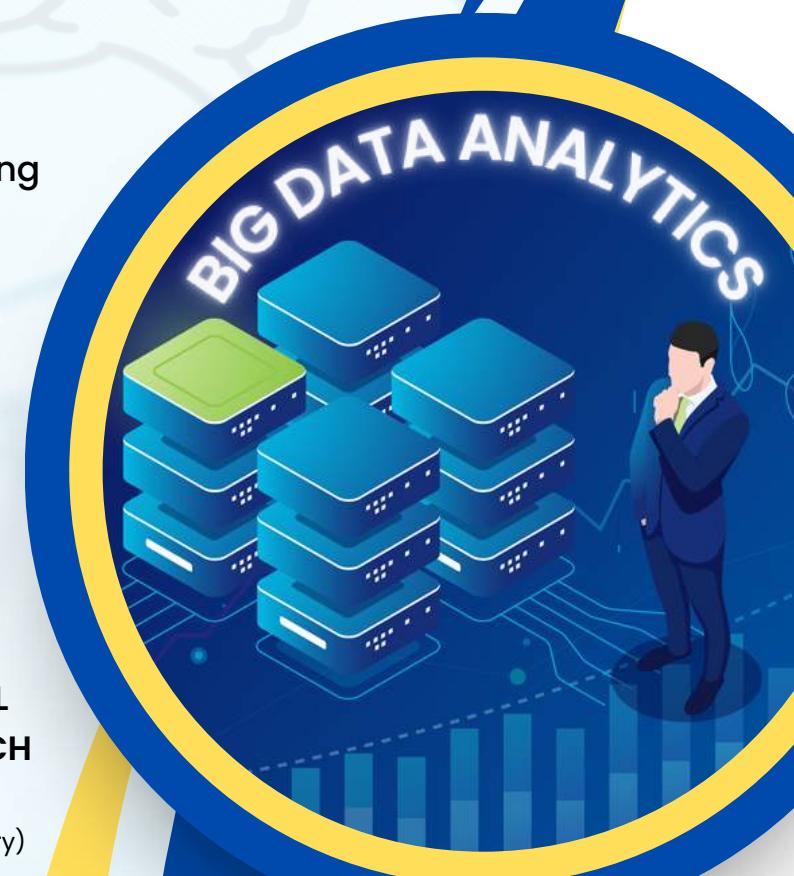
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Preface

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.
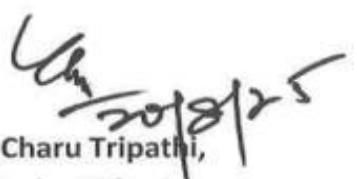
Prof. (Dr.) Chandra Charu Tripathi,
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2. Introduction:

Big data analytics is a branch of Computer Science which uses advanced analytics on large structured and unstructured data collections to produce valuable business insights. It is used widely across industries as varied as health care, entertainment, education, Banking, insurance, artificial intelligence, retail, manufacturing and many more to improve processes, systems, and profitability.

This M. Tech Programme in Computer Science and Engineering (Big data analytics) provides the students with in-depth knowledge and skills related to, data analytics, social network analysis, cyber-crime forensics and deep learning (DL). Big data analytics demands extensive use of mathematics and statistical methods to apply, therefore adequate inclusion of these types of contents through related courses is taken care of.

The programme consists of 4 offline spells and 2 online spells, totaling 80 credits. There is provision for student to exit the course after completing second offline spell followed by one additional exit course to enhance his/her skills in the area of big data analytics. The curriculum includes different courses to develop professional specific skills in the technology domain and in 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. Through these programme electives and special electives, each student can choose his/her pathway of completing the programme.

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

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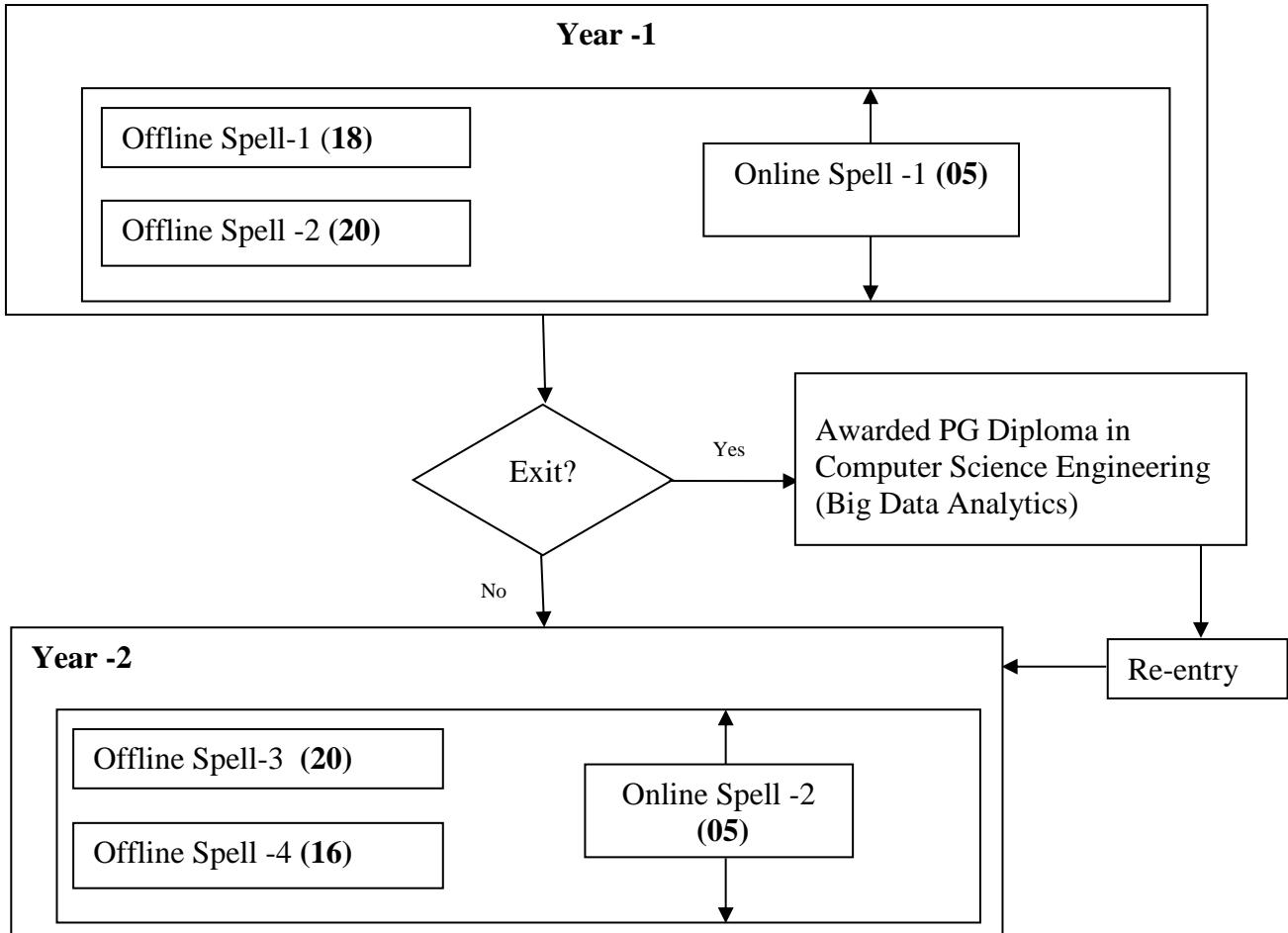
5. Vision & Mission Statements of the Institute:

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: Be an acknowledged centre of excellence in the area of Computer Science and Engineering Education, Research and Training, development and dissemination of application systems and software.

Mission: The department commits itself to accomplish following missions:
- Offer demand based long term and short-term education and training programs through various modes.
- Undertake researches in emerging & interdisciplinary areas of CSE, education & training, addressing contemporary academic, industrial/ professional, & societal issues.
- Undertake Outcome Based Curriculum Development in emerging areas of Computer Science & Engineering/IT.
- Develop and disseminate application systems, software & LRs for the client systems and the Institute.
- Network with industries, national and international institutions, R & D, community & service organisations for synergic partnership.

7. Programme Educational Objectives (PEOs):

PEO1:   Be a successful technical/professional in educational institutions.

PEO2:   Have a successful technical/professional career in IT industries/ research & other organisations.

PEO3:   Pursue higher studies and continue their professional development.

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

PEO5:   Be a successful Entrepreneur to provide services in Information technology and allied areas

8.   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 specialisation of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO-4   Use descriptive statistics for decision-making using AI by organising, analysing, and visualising large, complex datasets while maintaining the security and quality of data to ensure its access control and accuracy.

PO-5   Analyze datasets with supervised learning methods for functional approximation, classification, and forecasting, and unsupervised learning methods for dimensionality reduction and clustering.

PO-6   Manage the security and quality of data to ensure its access control and accuracy.

9.   Employment Potential:

Sample Employment and self-employment avenues are mentioned below-

9.1   Employment Avenues:

- Data Scientist
- Data Analyst
- Business Analyst
- Data Security Engineer
- Cloud Data Analyst
- Cloud Engineer

- Ai/Ml Specialist for Drug Development Applications
- Big Data Tester
- Database Manager
- Big Data Developer
- Data Governance Consultant
- Database Administrator and Big Data Engineer

9.2   Self-Employment Avenues:

- Freelance Data Consultant
- Data Science as a Service
- Build and Sell Data Products
- Start a Data focused Company
- Online Educator or Course Creator
- AI and Data Automation Services for Business
- ETL (Extract, Transform, Load) Services
- Consulting for Non-Tech Domains
- AI / ML consultant and Freelancer
- AI Mobile App Development

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

1.	**Title of Programme**	:	M. Tech. in Computer Science Engineering (Big Data Analytics)
2.	**Board of Studies**	:	Computer Science Engineering (Big Data Analytics)
3.	**Duration of Programme**	:	Two Years
4.	**Entry Qualification**	:	B. Tech./ B.E.
5.	**Total Marks**	:	3840
6.	**Total Credits**	:	85
7.	**Total Number of Courses**	:	22

Summary of Credits and Marks

S. No	Spell	Credits	Total Marks
	Year -1		
1.	Offline Spell - 1	19	800
2.	Offline Spell –2	20	830
3.	Online Spell – 1 (PD& NEP)	05	250
	Total	**44**	**1880**
	Year-2		
4.	Offline Spell - 3	20	910
5.	Offline Spell - 4	16	800
6.	Online Spell – 2 (PD & NEP)	05	250
	Total	**41**	**1960**
	Grand Total	**85**	**3840**

Category wise Courses

S. No.	Course Category	Abbreviations	Number of Courses	Total Credits
1.	Programme Core Courses	PCC	07	25
2.	Programme Elective Courses	PEC	02	08
3.	Stream Specific Diversified Courses (if applicable)	SSC	03	12
4.	Open Elective Courses (Common Basket)	OEC	-	-
5.	Project, Dissertation	PD	03	29
6.	Pedagogy Courses	PC	04	08
7.	NEP Courses	NEP	03	03
	Total		**22**	**85**

Computer Science Engineering (Big Data Analytics)- CSEB
Teaching & Learning and Assessment Scheme (<u>Year – 1</u>)
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)	
CSEB01	PCC	**Statistical Computing**	30	15	-	45	90	03	30	70	20	-	-	-	120
CSEB02	PCC	**Foundation of Big Data Analytics**	30	15	45	30	120	04	30	70	20	-	20	30	170
CSEB03	PCC	**Distributed Systems**	30	15	-	45	90	03	30	70	20	-	-	-	120
CSEB04	PCC	**Machine Learning using Big Data**	30	15	45	30	120	04	30	70	20	-	20	30	170
CSEB05	PCC	**Basics of Artificial Intelligence and Machine Learning**	30	15	45	30	120	04	30	70	20	-	20	30	170
NEP01-05	NEP*	**NEP Courses**	15	-	-	15	30	01	25	-	25	-	-	-	50
		Total	**165**	**75**	**135**	**195**	**570**	**19**	**175**	**350**	**125**	**-**	**60**	**90**	**800**

Legends:

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

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

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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)	
CSEB06	PCC	Information Retrieval Techniques	30	15	45	30	120	04	30	70	20	-	20	30	170
CSEB07	PCC	Data Governance and Security	30	15	-	45	90	03	30	70	20	-	-	-	120
CSEB08-09	PEC	Programme Elective Course -1	30	15	30	45	120	04	30	70	20	-	20	30	170
CSEB10-11	PEC	Programme Elective Course -2	45	15	30	30	120	04	30	70	20	-	20	30	170
PD01	PD	Project	-	-	45	105	150	05	-	-	200	-	-	-	200
		Total	135	60	150	255	600	20	120	280	280	-	60	90	830

Legends:

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

Programme Elective Course -1: Big Data Tools (CSEB08)/ Advanced Data Modeling (CSEB09)
Programme Elective Course -2: Streaming Data Analytics (CSEB10)/ Next Generation Databases (CSEB11)

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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)	
CSEB12-16	SSC	**Stream Specific Diversified Course-1**	30	15	45	30	120	04	30	70	20	-	20	30	170
CSEB17-21	SSC	**Stream Specific Diversified Course -2**	30	15	45	30	120	04	30	70	20	-	20	30	170
CSEB22-26	SSC	**Stream Specific Diversified Course -3**	30	15	45	30	120	04	30	70	20	-	20	30	170
PD02	PD	**Dissertation Part -I**	-	-	90	150	240	08	-	-	300	100	-	-	400
		Total	90	45	225	240	600	20	90	210	360	100	60	90	910

Legends:

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

Stream Specific Diversified Course-1 (Healthcare Basket (HC)): Introduction to Health Informatics (CSEB12)/ Big Data in Biology (SCEB13)/ Human-Computer Interaction (CSEB14)/ Computer Vision (CSEB15)/ Climate Change Analytics (CSEB16)

Stream Specific Diversified Course -2 (Social Network and Business Analysis Basket (SN)): Geospatial Information Systems (CSEB17)/ Social Networking and Mining (CSEB18)/ Data Technology Solutions for Big Data (CSEB19)/ Big Data Visualization for Business (CSEB20)/ Time Series Analysis for Business Forecasting (CSEB21)

Stream Specific Diversified Course -3 (System Security Basket (SS)): Information Security and Analysis (CSEB22)/ Cyber Crime and Forensics (CSEB23) / Block Chain Technology (CSEB24)/ Quantum Computing (CSEB25)/ Cyber Physical Systems (CSEB26)

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

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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 in parallel with offline spell-3 and offline spell-4 in the 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)

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Course Curriculum Detailing- Offline Spell -1

A)	**Course Title:** Statistical Computing
B)	**Course Code:** CSEB01
C)	**Pre-requisite (s):** Python Programming

D) **Rationale:** In order to make sophisticated decisions, extracting meaningful insights from the stored data requires the appropriate use of statistical methods. This course provides the foundational knowledge and practical skills to effectively analyse, interpret, and model large-scale data. Students will learn to implement and apply various statistical techniques, including hypothesis testing, regression analysis, and multivariate methods, using specialized software and programming languages. This empowers them to validate models, identify trends, and make data-driven decisions, which are critical competencies for any big data professional.

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
CSEB01.CO1	Find the basic descriptive measures to quantify the uncertainty for any real-time application using probability.
CSEB01.CO2	Apply the various discrete and continuous probability distributions to the given dataset.
CSEB01.CO3	Develop a simple linear regression model to predict the associations in data.
CSEB01.CO4	Construct a sampling method for the given scenario.
CSEB01.CO5	Perform a suitable statistical test for the given scenario.

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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/docume nt.	**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** Use descriptive statistics for decisions making by organizing, analyzing, and visualizing large complex datasets.	**PO-5** Analyze datasets with supervised learning methods for functional approximation, classification, and forecasting and unsupervised learning methods for dimensionality reduction and clustering.	**PO-6** Manage the security and quality of data to ensure its access control and accuracy.
CSEB01.CO1	3	3	3	-	1	-
CSEB01.CO2	3	3	2	3	3	-
CSEB01.CO3	3	3	2	2	2	-
CSEB01.CO4	3	3	3	3	3	-
CSEB01.CO5	3	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)	
CSEB01	PCC	Statistical Computing	30	15	-	45	90	03	30	70	20	-	-	-	120

H)   Course Curriculum Detailing:
For attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom, laboratories/ workshops/ term work, self-learning/ field sessions. As per the requirements of NEP: 2020, unique features like Green skills, Multidisciplinary Aspects, Societal Connect, IKS, Renewable Energy are integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Explain statistics TSO 1b. Calculate appropriate measures of central tendency. TSO 1c. Differentiate the continuous and discrete variables. TSO 1d. Find moments of distribution for a dataset TSO 1e. Use the moment-generating function (MGF) for a random variable. TSO 1f. Find the relationship between the variables using joint distributions. TSO 1g. Differentiate the marginal and conditional distributions. TSO 1h. Find the distribution of power consumption using the transformation of random variables.	**Unit-1.0 Probability and Random Variables** 1.1 Statistics 1.2 Measures of Central Tendency 1.3 Discrete and continuous random variables 1.4 Moments of distribution 1.5 Moment generating functions 1.6 Joint distributions 1.7 Marginal and conditional distributions 1.8 Transformation of random variables.	CO1
TSO 2a. Explain the Concept of probability. TSO 2b. Use the concepts of the Axioms of Probability for developing complex probability calculations TSO 2c. Explain the concept of conditional probability. TSO 2d. Apply Bayes' Theorem to update the probability of a hypothesis TSO 2e. Find the expected value of a discrete random variable TSO 2f. Compute the probability of the likelihood of an event using the Binomial Distribution TSO 2g. Demonstrate the Poisson distribution process. TSO 2h. Use Poisson distribution for analyzing the rare events. TSO 2i. Use Geometric distribution to predict the future sales. TSO 2j. Generate the keys using Uniform distribution. TSO 2k. Predict a lifespan of an electronic device by using exponential distribution. TSO 2l. Find the confidence intervals for a population prediction model using normal distribution. TSO 2m. Use limit theorem to quantify the uncertainty of an estimation. TSO 2n. Demonstrate the prediction process using stochastic process. TSO 2o. Perform the feature selection process on a dataset using HMM.	**Unit 2.0: Probability Distributions and Central Limit Theorem** 2.1 Probability 2.2 Axioms of probability 2.3 Conditional probability 2.4 Bayes' theorem 2.5 Expectations 2.6 Binomial Distribution 2.7 Poisson distribution 2.8 Geometric Distribution 2.9 Uniform Distribution 2.10 Exponential and Normal distributions 2.11 Central limit theorem (for independent and identically distributed random variables) 2.12 Stochastic process 2.13 Hidden Markov Model	CO2

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 3a. Identify the relationship between the two companies' financial instruments using correlation. *TSO 3b.* Find the performance differences between the students in various assessment methods using rank correlation methods. *TSO 3c.* Predict the price of a product by conducting regression analysis. *TSO 3d.* Use a regression equation to simulate a scenario and identify the expected outcome. *TSO 3e.* Predict the future demand of a product by using time series analysis. *TSO 3f.* Find the best-fit curve for the given dataset using curve fitting. *TSO 3g.* Use the Method of Least Squares for predicting the future by analyzing the given dataset.	**Unit-3.0 Correlation and Regression Analysis** 3.1 Correlation 3.2 Rank Correlation 3.3 Regression analysis 3.4 Regression Equations 3.5 Partial and Multiple Correlation 3.6 Time series Analysis 3.7 Curve Fitting 3.8 Method of Least Squares.	CO3
TSO 4a. Use unbiased estimators to provide accurate insights from sample data. *TSO 4b.* Derive preliminary estimates for parameters of a dataset which has the various customer arrival times based on observed sample moments. *TSO 4c.* Predict the insurance risk of a human by analyzing the historical data using the method of maximum likelihood. *TSO 4d.* Find the uncertainty level of a survey using interval estimation of means. *TSO 4e.* Differentiate the means, variations and ratio of two variances on a simple dataset. *TSO 4f.* Apply sampling theories to represent the data to ensure the optimal resource utilization. *TSO 4g.* Evaluate the statistical significance of effects in a sampled data. *TSO 4h.* Apply T-test to validate a classifier result. *TSO 4i.* Apply Chi-Square test on a prediction model and ensure the effectiveness. *TSO 4j.* Use F-Test to verify the market prediction *TSO 4k.* Find impactful factors of sales revenue in a production company by conducting ANOVA test.	**Unit-4.0 Theory of Estimation and Sampling** 4.1 Unbiased estimators: Efficiency – Consistency – Sufficiency – Robustness 4.2 Method of moments 4.3 Method of maximum Likelihood 4.4 Interval estimation of Means 4.5 Differences between means, variations and ratio of two variances 4.6 Sampling Theory: Small and Large Sampling 4.7 Theory of Inference 4.8 Testing of Hypothesis- t-test, Chi-Square Test and F-Test 4.9 Analysis of Variances (ANOVA)	CO4
TSO 5a. Use the statistical modelling on applications.	**Unit 5.0: Statistical Analysis with Python** 5.1 Statistical modelling with python	CO5

Major Theory Session Outcomes (TSOs)		Units		Relevant CO Number(s)
TSO 5b.	Apply fitting statistical models to quantify the changes of independent variables to enable optimization of a business method.	5.2	Fitting statistical models to independent and dependent data	
TSO 5c.	Find the underlying probability distributions of observed data on anomaly detection process.	5.3	Probability Distributions with Python	
TSO 5d.	Use suitable testing of hypothesis with Python	5.4	Statistical Inference procedures	
TSO 5e.	Perform correlation analysis on a dataset using Python program.	5.5	Testing of Hypothesis with Python - T-tests, ANOVA, Chi-square tests	
TSO 5f.	Apply regression analysis on a dataset using Python program.	5.6	Correlation and Regression Analysis with Python	
TSO 5g.	Demonstrate the time series analysis for the given dataset through Python program.	5.7	Time Series Analysis with Python	

J)   Suggested Laboratory Experiences: (Not Applicable)

K)   Suggested Research Based Problems:

   i. Demonstrate the performance of the SVM over a seizer dataset with respect to the detection accuracy and perform the Chi-Square test.
   ii. Develop a product recommendation system using decision tree algorithm by analyzing a sales dataset. Moreover, the system needs to recommend the product requirement for the specific year and the required quantity to fulfill the customer needs with satisfaction. Conduct the T-test analysis.

   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:

   - Probability in Decision Making
   - Sampling Theory in Statistical Computing
   - Hypothesis Test in Statistical Computing
   - Correlation Analysis Vs Regression Analysis
   - Role of Binomial Distribution in Statistical Analysis
   - Role of Poison Distribution in Statistical Analysis

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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 Probability and Random Variables	14
CO2	Unit 2.0: Probability Distributions and Central Limit Theorem	14
CO3	Unit-3.0 Correlation and Regression Analysis	14
CO4	Unit-4.0 Theory of Estimation and Sampling	14
CO5	Unit 5.0: Statistical Analysis with Python	14
Total		**70**

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

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

P) **Suggested Learning Resources:**

   a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Fundamentals of Mathematical Statistics	S. C. Gupta and V. K. Kapoor	Sultan Chand and Sons; 12th Edition, 2020.
2.	Mathematics For Machine Learning	Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong	Cambridge University Press, 2020
3.	Probability and Statistics for Data Science	Carlos Fernandez-Granda	Cambridge University Press, 2025.
4.	Statistical Methods	S.P.Gupta	Sultan Chand and Sons; 46th Edition, 2021.
5.	An Introduction to Statistical Learning: With Applications in Python	Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, Jonathan Taylor	Springer Nature, 2023.
6.	Python for Programmers	Paul Deitel and Harvey Deitel	Pearson Education, 1st Edition, 2021

b) Online Educational Resources (OER):

1) https://www.w3schools.com/python/
2) https://www.geeksforgeeks.org/machine-learning/statistics-for-machine-learning/
3) https://www.coursera.org/learn/machine-learning-probability-and-statistics
4) https://rss.org.uk/membership/rss-groups-and-committees/sections/statistical-computing/
5) https://onlinecourses.nptel.ac.in/noc25_cs136/preview
6) https://www.geeksforgeeks.org/competitive-exam-experiences/nptel-journey-as-a-introduction-to-machine-learning-course-certification/

7) **Data Sources:**
   - https://www.kaggle.com/datasets
   - https://archive.ics.uci.edu/ml/machine-learning-databases/auto-mpg/
   - https://archive.ics.uci.edu/ml/machine-learning-databases/iris/iris.data

Q) Course Curriculum Development Team

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A)	**Course Title:** Foundations of Big Data Analytics
B)	**Course Code:** CSEB02
C)	**Pre- requisite (s):** Machine Learning

R)   Rationale: Big data is a collection of large and complex data sets that can be used to solve business problems and make informed decisions. The course is designed to provide a comprehensive understanding of big data concepts, technologies, tools, and applications. It also provides a comprehensive thought of the challenges and solutions in Big Data security and privacy, focusing on real-world tools and technologies through hands-on practical. The course will also serve as a prerequisite to many other courses to be offered in the following semesters.

S)   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
CSEB02.CO1	Perform data storage, and processing operations on big data
CSEB02.CO2	Analyse big data using various tools and frameworks.
CSEB02.CO3	Use Spark SQL for querying external data with complex analytics
CSEB02.CO4	Visualize the data appropriately using different tools and techniques
CSEB02.CO5	Implement big data security mechanism using different techniques

T)   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/docume nt.	**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** Use descriptive statistics for decisions making by organizing, analyzing, and visualizing large complex datasets.	**PO-5** Analyze datasets with supervised learning methods for functional approximation, classification, and forecasting and unsupervised learning methods for dimensionality reduction and clustering.	**PO-6** Manage the security and quality of data to ensure its access control and accuracy.
CSEB02.CO1	2	2	2	2	2	2
CSEB02.CO2	3	3	2	2	2	2
CSEB02.CO3	3	3	2	3	2	2
CSEB02.CO4	1	2	2	1	2	-
CSEB02.CO5	1	1	2	3	3	2

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

U)   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)	
CSEB02	PCC	Foundation of Big Data Analytics	30	15	45	30	120	04	30	70	20	-	20	30	170

V)   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.

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W) Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)

TSO 1a. Analyze the characteristics of big data
TSO 1b. Examine the characteristics of different types of data in view of consequences of their processing techniques
TSO 1c. Explain the concept of data quality and cleanliness with their implications in data analytics process
TSO 1d. Explain Steps to Perform Data Cleanliness operations
	Unit-1.0 Introduction to Big Data
	
	1.1 Definition and characteristics of big data- Volume, Velocity, Variety, Veracity, Value
	1.2 Historical context and evolution of data management
	1.3 Applications of big data in various domains
	1.4 Data sources and types: Structured, semi-structured, and unstructured data
	  1.4.1 Data generation sources - IoT, social media, transactional data.
	  1.4.2 Introduction to data quality and data cleaning
	  1.4.3 Steps to Perform Data Cleanliness; Removal of Unwanted Observations, Fixing Structure errors, Managing Unwanted outliers, Handling Missing Data
		CO1

TSO 2a. Compare Traditional databases with NoSQL databases
TSO 2b. Interpret the architecture of HDFS
TSO 2c. Illustrate the architecture of Hadoop
TSO 2d. Analyze the mechanism for distributed storage and distributed processing in Hadoop
TSO 2e. Explain the process of MapReduce with its different phases.
	Unit-2.0 Data Storage Technologies
	
	2.1 Traditional databases vs. NoSQL databases
	2.2 Overview of data lakes and data warehouses
	2.3 Introduction to Hadoop and HDFS
	  • Basics of HDFS
	  • The architecture of HDFS
	  • Roles of NameNode and DataNode.
	  • Process of storing, replication, and distribution of data across Hadoop Cluster
	  • Fault tolerance mechanisms in HDFS and data recovery processes
	2.4 Hadoop Architecture
	  • Introduction to Apache Hadoop and its ecosystem
	  • Layers and components of Hadoop architecture.
	  • The significance of MapReduce in Hadoop architecture
	2.5 MapReduce programming model
	  • Different phases of MapReduce
	  • Mapper phase and Reducer phase
	  • MapReduce anatomy
		CO2

TSO 3a. Compare MapReduce and Spark on different parameters *TSO 3b.* Analyze various components of spark architecture.	**Unit-3.0 Data Processing with Spark** 3.1 Overview of Apache Spark and its ecosystem, Comparison of MapReduce and Spark	CO3

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 3c. Explain the features of MLlib in Spark as a big data analytics Tool *TSO 3d.* Investigate the aspects of Performance Tuning and Optimization using spark *TSO 3e.* Analyze the points of considerations while using streaming data processing	3.2 Spark Architecture: Driver, Executors, and Cluster Manager 3.3 Resilient Distributed Dataset (RDDs), Data Frames, and Datasets, Schema and the Catalyst optimizer 3.4 Reading from and writing to various data sources (HDFS, S3, JDBC, Kafka) 3.5 Spark SQL and DataFrames API 3.6 Optimizing data processing with partitioning, caching, and check pointing 3.7 Resource management in Spark: Memory, CPU, and task parallelism 3.8 Tools for big data analytics (ML lib in Spark) 3.9 Streaming data processing with Spark Streaming	
TSO 4a. Compare various Tools and libraries for data visualization. *TSO 4b.* Explain the use of different types of charts *TSO 4c.* Explain the procedure of creating different types of charts using Matplotlib *TSO 4d.* Create different types of charts to represent data graphically using matplotlib *TSO 4e.* Illustrate different techniques of customizing Plots for enriching the data visualization *TSO 4f.* Explain the features of PyPlotAPI with Matplotlib	**Unit- 4.0 Data Visualization Techniques** 4.1 Importance of data visualization 4.2 Tools and libraries for data visualization (Tableau, Matplotlib, Seaborn) 4.3 Data Visualization: Introduction to Matplotlib, PyPlot package, Figures and Subplots, showing plots and images 4.4 Chart types: Line, Bar, stacked bar, Box plots, pie chart, Histogram and Density plots, Scatter plot, Saving Plots to a file, Close and clear plots. 4.5 Customizing Plots: Colors, Markers, Line Styles, Limits, Tics, Labels, Legends, Grids, Annotating with text, Matplotlib Configuration	CO4
TSO 5a. Explain key concepts of data integrity and availability *TSO 5b.* Illustrate common threats and attacks in big data *TSO 5c.* Contrast the characteristics of Attribute-Based Access Control and Role-Based Access Control *TSO 5d.* Investigate Data protection, Data governance and compliance laws of India, Europe and USA *TSO 5e.* Apply cryptography techniques for securing big data environments *TSO 5f.* Interpret best practices in Big Data governance and ethics	**Unit- 5.0 Big Data Security and Privacy** 5.1 Data security and privacy concerns in big data 5.2 Key concepts: Confidentiality, Integrity, and Availability (CIA triad) 5.3 Common threats and attacks in Big Data-data breaches, insider threats, unauthorize access, DDoS 5.4 Attribute-Based Access Control (ABAC) vs. Role-Based Access Control (RBAC). 5.5 Data governance and compliance Digital Personal Data Protection Act 2023 (DPDPA), GDPR, CCPA	CO5

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Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
	5.6 Techniques for securing big data environments, big data with cryptography, ECC for big data 5.7 Ethical considerations in big data analytics	

X)   Suggested Laboratory Experiences:

Practical/Lab Session Outcomes (LSOs)		S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
LSO 1.1.	Perform Data Cleanliness operations using Python.	1.	**Take a dataset Titanic and perform following operations on it:** a) Check the data information by inspecting the structure of data and identify- missing values, outliers, and inconsistencies and check the duplicate rows. b) Drop Observations with missing values. c) Impute the missing values from past observations d) Transform the data by applying Techniques such as Min-Max scaling and Standardization (Z-score scaling)	CO1
LSO 1.2.	Develop insight about real world problems and use data analytics techniques to solve these problems	2.	Case study analysis of big data applications in healthcare, finance, and marketing	CO1
LSO 2.1.	Use Apache Hadoop on local system.	3a.	Install Apache Hadoop on a local system.	CO2
LSO 2.2.	Create a MapReduce program to solve a given problem.	3b.	Develop a MapReduce program to calculate the frequency of a given word in a given file.	CO2
LSO 2.3.	Monitor MapReduce Job execution time.	3c.	Develop a MapReduce program to find the grades of students.	CO2
LSO 2.4.	Calculate the number of mappers, reducers, and the data processed	3d.	Develop a MapReduce to analyze weather data set and print whether the day is shinny or cloudy day.	CO2
LSO 3.1.	Analyze large datasets using Spark SQL	4.	Perform following data analytics operations using Apache Spark (take a large dataset): a) Classification and regression b) Collaborative filtering c) Clustering d) Dimension reduction	CO3
LSO 3.2.	Create, transform, and process Resilient Distributed Datasets (RDDs)	5.	Using Apache spark framework: a) Perform transformations like filtering and mapping.	CO3

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Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
		b) Implement an aggregation operation such as reducing or counting values by key. c) Analyze and optimize the performance of RDD operations using the Spark UI	
LSO 3.3. Process structured data using DataFrames and Spark SQL	6.	Using Apache spark framework: a) Use DataFrame API to clean and transform data (filter, group, aggregate). b) Write Spark SQL queries to perform complex transformations (joins, window functions). c) Register the DataFrame as a temporary table and query it using SQL. d) Write the processed data back to disk in a structured format (Parquet)	CO3
LSO 4.1. Visualize the data using matplotlib	7.	Apply following visualization techniques using matplotlib (take a sample dataset): a) Create a simple line plot to visualize a dataset b) Create a bar chart to compare different categories c) Visualize the distribution of a dataset using a histogram d) Create a scatter plot to visualize the relationship between two variables	CO4
LSO 4.2. Use matplotlib for advanced Data Visualization	8.	Create following types of graphs using appropriate dataset: a) Create interactive plots with sliders, buttons, or checkboxes b) Plot a 3D surface plot for a mathematical function like z = sin(x) * cos(y) c) Plot two related datasets with a shared x-axis for better comparison d) Create a custom color map to visualize temperature variations across a geographic region. e) Highlight key points in a plot like maxima, minima, or inflection points f) Plot stock market data and add features like rolling averages, with custom markers for specific events (e.g., earnings announcements) g) Generate a 2D scatter plot of data with overlaid density contours to show point concentrations	CO4

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number (s)
LSO 5.1. Implement Attribute-Based Access Control (ABAC) in Big Data Systems	9.	Implement Attribute-Based Access Control (ABAC) in a distributed big data environment using Apache Ranger to enforce security policies by performing following tasks: 1. **Define ABAC policies** based on different attributes like user roles, data sensitivity, and operations 2. **Create policies for fine-grained access control** to different data sets in Hadoop 3. **Test and validate access control** by simulating users with different attributes and permissions 4. Explore the way **dynamic attributes (like time-based access)** can enhance security	CO5
LSO 5.2. Preserve Privacy in Big Data using Differential Privacy	10.	Implement differential privacy algorithms on a large dataset to ensure data privacy when performing statistical queries	CO5
LSO 5.3. Apply Big Data Encryption and Secure Storage Using Advanced Encryption Standard (AES) and HDFS Encryption Zones	11.	Implement data encryption in a big data system, securing stored data using AES encryption and HDFS encryption zones in Hadoop.	CO5

Y) Suggested Research Based Problems:

i.   Explore any two different visualization tools and compare their feature with the Matplotlib. Prepare a report and present it.

ii. Identify security and privacy risks in a Big Data environment

- Choose a real-world dataset (e.g., public health data).
- Analyze potential security threats (e.g., unauthorized access, data corruption).
- Evaluate privacy risks (e.g., re-identification of individuals).
- Document the key vulnerabilities and suggest mitigation strategies.
- Perform sentiment analysis on Twitter or Reddit data to understand public opinion on a particular topic (use tools such as Tweepy (for Twitter API), TextBlob/NLTK for sentiment analysis, Apache Spark for processing large datasets
- Prepare a report on The Future of Big Data: Trends, Opportunities, and Challenges.

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.

Z)   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.

    b. Seminar Topics:

- Comparing Hadoop's MapReduce framework with Apache Spark for distributed data processing
- Emerging Trends in Big Data: Edge Computing and Data Lakes.
- Challenges of protecting data in Big Data environments
- Predictive Analytics and Big Data for Business Intelligence

AA)   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 Big data	12
CO2	Unit 2.0: Data Storage Technologies	16
CO3	Unit 3.0: Data Processing with Spark	18
CO4	Unit 4.0: Data Visualization Techniques	8
CO5	Unit 5.0: Big Data Security and Privacy	16
Total		**70**

BB)   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.

CC)   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.	RDBMS Software	MySQL/Oracle/SQL Server/MongoDB	All
3.	Hadoop MapReduce	-	All
4.	Apache Spark	-	All

DD)   Suggested Learning Resources:

a)   Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Ultimate Big Data Analytics with Apache Hadoop	Simhadri Govindappa	Orange Education Pvt Ltd, AVA ISBN: 9788197396571 e-ISBN: 9788197396519
2.	Big Data Analytics: Introduction to Hadoop, Spark, and Machine-Learning	Raj Kamal (Author), Preeti Saxena (Author)	McGraw Hill Education (India) Private Limited, ISBN-10: 9353164966, ISBN-13: 978-9353164966
3.	Big Data Fundamentals	Erl/Khattak/Buhler	Pearson Education India; First Edition ISBN-10: 818489323X, ISBN-13: 978-9332575073

b)   Online Educational Resources (OER):

1) MOOC on Apache spark: https://www.coursera.org/lecture/big-data-integration-processing/introduction-to-apache-spark-F7SFX
2) Tutorial on Hadoop and Mapreduce: https://www.simplilearn.com/tutorials/hadoop-tutorial
3) Tutorial on Matplotlib: https://matplotlib.org/stable/tutorials/index.html
4) Matplotlib and PyPlottutorial:https://www.tutorialspoint.com/matplotlib/index.htm
5) Data Source
   - https://www.kaggle.com
   - Titanic dataset

EE)   Course Curriculum Developer

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A)	**Course Title:** Distributed Systems
B)	**Course Code:** CSEB03
C)	**Pre- requisite (s):**

D)   Rationale: The components of a distributed system communicate and coordinate their actions by passing messages to one another in order to achieve a common goal. Three significant challenges of distributed systems are: maintaining concurrency of components, overcoming the lack of a global clock, and managing the independent failure of components Distributed Computing offers several significant advantages over traditional single-system computing. These include scalability and availability. Scalability: Distributed systems can easily grow with workload and requirements, allowing for the addition of new nodes as needed. Availability: These systems exhibit high fault tolerance.

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
CSEB03.CO1	Explain the fundamentals of distributed systems.
CSEB03.CO2	Develop distributed objects and processes for the distributed systems.
CSEB03.CO3	Explain the Issues of Operating System in distributed environment.
CSEB03.CO4	Perform the distributed transaction processing using algorithms.
CSEB03.CO5	Evaluate the distributed algorithms by considering the necessary evaluation metrics.

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/documen t.	**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** Use descriptive statistics for decisions making by organizing, analyzing, and visualizing large complex datasets.	**PO-5** Analyze datasets with supervised learning methods for functional approximation, classification, and forecasting and unsupervised learning methods for dimensionality reduction and clustering.	**PO-6** Manage the security and quality of data to ensure its access control and accuracy.
CSEB03.CO1	3	3	2	2	2	-
CSEB03.CO2	3	3	3	3	2	-
CSEB03.CO3	3	3	3	2	2	-
CSEB03.CO4	3	3	3	3	2	-
CSEB03.CO5	2	3	2	2	2	-

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

G)   Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
CSEB03	PCC	Distributed Systems	30	15	-	45	90	03	30	70	20	-	-	-	120

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

I)   Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Explain the distributed systems with examples TSO 1b. Differentiate the system models. TSO 1c. Differentiate the external data representation and marshalling TSO 1d. Illustrate client server communication and group communication.	**Unit-1.0 Basic Concepts** 1.1 Definition of a distributed systems, Examples 1.2 Resource sharing and the Web, Challenges 1.3 System models 1.4 Architectural and fundamental models 1.5 Networking Inter-process communication 1.6 External data representation and marshalling 1.7 Client-server and Group communication	**CO1**

TSO 2a.   Create a remote procedure call a specific task
TSO 2b. Use events and notifications
TSO 2c. Differentiate the process and threats
TSO 2d. Apply protection in OS layer
TSO 2e. Apply cryptographic algorithms to secure the data in distributed environment
	Unit-2.0 Distributed Objects and Process
	
	2.1 Distributed objects and remote invocation
	2.2 Communication between distributed objects
	2.3 Remote procedure call
	2.4 Events and notifications
	2.5 The operating system layer
	2.6 Protection
	2.7 Processes and Threads
	2.8 Communication and invocation
	2.9 OS Architecture.
	2.10 Security techniques
	   • Cryptographic algorithms
	   • Access control
	   • Digital signatures
	   • Cryptography pragmatics
	   • Needham-Schroeder
	   • Kerberos
	   • Securing electronics transactions and IEEE 802.11 WiFi
		CO2

TSO 3a. Differentiate the distributed file systems TSO 3b. Explain the name services TSO 3c. Differentiate the directory services and discovery services TSO 3d. Develop a file sharing system TSO 3e. Perform the distributed debugging	**Unit-3.0 Operating System Issues** 3.1 Distributed file systems 3.2 Name services 3.3 Domain name system 3.4 Directory and discovery services 3.5 Peer to peer systems 3.6 Napster file sharing system	**CO3**

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Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 3f. Perform the Distributed mutual exclusion *TSO 3g.* Use multicast communicationin a distributed environment.	3.7 Peer to peer middleware routing overlays 3.8 Clocks, Events and process states Clock Synchronization 3.9 Logical clocks Global states 3.10 Distributed debugging 3.11 Distributed mutual exclusion 3.12 Elections 3.13 Multicast communication	
TSO 4a. Differentiate the transactions and nested transactions. *TSO 4b.* Create a lock. *TSO 4c.* Apply optimistic concurrency control *TSO 4d.* Develop atomic commit protocol. *TSO 4e.* Create a transaction recovery *TSO 4f.* Use distributed shared memory	**Unit-4.0 Distributed Transaction Processing** 4.1 Transactions 4.2 Nested transactions 4.3 Locks 4.4 Optimistic concurrency control 4.5 Timestamp ordering 4.6 Flat and nested distributed transactions 4.7 Atomic commit protocols 4.8 Concurrency control in distributed transactions 4.9 Distributed deadlocks 4.10 Transaction recovery 4.11 Overview of replication 4.12 Distributed shared memory and Web services	**CO4**
TSO 5a. Differentiate the synchronous and Asynchronous model *TSO 5b.* Apply leader election. *TSO 5c.* Design an asynchronous shared model *TSO 5d.* Develop asynchronous shared model for a distributed environment. *TSO 5e.* Apply mutual exclusion *TSO 5f.* Design an Asynchronous network model by using necessary algorithms.	**Unit 5.0: Distributed Algorithms** 5.1 Synchronous network model 5.2 Algorithms: leader election, maximal independent set 5.3 Asynchronous system model: I/O automata, operations on automata, fairness 5.4 Asynchronous shared memory model 5.5 Mutual exclusion: model, the problem, stronger conditions, lockout 5.6 Free mutual exclusion algorithms, lower bound on the number of registers 5.7 Asynchronous network model 5.8 Asynchronous network algorithms: leader election in a ring and an arbitrary network.	**CO4 & CO5**

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J)   Suggested Laboratory Experiences: (Not Applicable)

Suggested Problems/Micro Projects: Problems/Micro projects may be designed for the attainment of identified COs/combination of COs

i.   Implement a simplified distributed key-value store where data is shared across multiple nodes. Focus on achieving eventual consistency or a weaker consistency model using techniques like vector clocks or simple time stamping for conflict resolution using Python/Java.

ii.   Implement a simple distributed task queue system where tasks can be submitted, processed by worker nodes, and are resilient to worker failures. Implement a basic heartbeat mechanism or a leader election to reassign tasks from failed workers using Python/Java.

iii.   Implement a distributed system where multiple processes need to access a shared critical section. Use the Token Ring algorithm to ensure mutual exclusion, demonstrating how only one process at a time can enter the critical section using Python/java.

iv.   Build a simple decentralized chat application where users connect directly to each other without a central server for message routing using Python/JavaScript.

K)   Suggested Research Based Problems

i.   The Develop an optimized 2PC variant model that improves transaction throughput and reduces   latency in distributed micro services while maintaining transactional integrity. The proposed 2PC model needs to be developed with the incorporation of a new dynamic selection method and recovery mechanism to reduce the overhead, service independence and impacts of the current transactions. Evaluate the model by considering the necessary evaluation metrics.

ii.   Develop a distributed consensus algorithm variant tailored for edge computing, demonstrating improved resilience to failures and higher efficiency compared to traditional approaches. This algorithm needs to adapt the disconnections, reconnections, ensuring continuous agreement and edge environments.

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.
- Distributed Transactions and Concurrency Control
- Distributed Deadlock Detection and Prevention
- Clock Synchronization and Logic Clocks (Lamport, Vector Clocks)
- Content Delivery Networks (CDNs): Architecture and Optimization
- Distributed Storage Systems: Architectures and Trade-offs

b. Seminar Topics:

- Consensus Algorithms: A deep drive into Paxos and Raft
- Fault Tolerance and Replication Strategies in Distributed Systems
- Event-Driven Architectures and Message Queues in Distributed Systems
- Distributed Machine Learning: Training and Inference at Scale
- Distributed Graph Processing Systems
- Quantum Computing and its Potential Impact on Distributed Systems

c. Self- Learning:

- Industrial visit
- Any other activity

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 Basic Concepts	14
CO2	Unit 2.0 Distributed Objects and Process	14
CO3	Unit 3.0 Operating System Issues	14
CO4	Unit 4.0 Distributed Transaction Processing	14
CO5	Unit 5.0 Distributed Algorithms	14
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:** (Not Applicable)

P)   Suggested Learning Resources:

  a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Distributed Systems: Concepts and Design	George Coulouris, Jean Dollimore, Tim Kindberg, Gordon Blair	Pearson Education, ISBN-13: 978-0132143011
2.	Distributed Systems: Principles and Paradigms	Andrew S. Tanenbaum, Maarten van Steen	Pearson (Prentice Hall), 2nd Edition, ISBN-13 978-0132392271
3.	Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Systems	Martin Kleppmann	O'Reilly Media, 2017. ISBN-13: 978-1449373320
4.	Distributed Algorithms	Nancy A. Lynch	Morgan Kaufmann, 1996. ISBN-13: 978-1558603486
5.	Distributed Operating Systems and Algorithm Analysis	Randy Chow, Mohamed G. F. F. G. Hussain	Pearson (Prentice Hall), 1997. ISBN-13: 978-0201183372

b) Online Educational Resources (OER):

1) https://pdos.csail.mit.edu/6.824/
2) https://www.geeksforgeeks.org/distributed-systems-tutorial/
3) https://www.edx.org/learn/computer-science/delft-university-of-technology-modern-distributed-systems
4) https://swayam.gov.in/nd1_noc19_cs63/preview
5) https://swayam.gov.in/nd1_noc20_cs66/preview
6) https://news.ycombinator.com/item?id=23723513
7) https://vowi.fsinf.at/images/6/63/TU_Wien-Verteilte_Systeme_VO_%28Dustdar%29_-_ZusammenfassungWS22.pdf

Q)   Course Curriculum Developer

S. No.	Name	E-mail Address
1.	Prof. S. Ganapathy	sganapathy@nitttrbpl.ac.in

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A)	**Course Title:** Machine Learning using Big Data
B)	**Course Code:** CSEB04
C)	**Pre- requisite (s):** Machine Learning

D) Rationale: In the era of data abundance, the convergence of machine learning (ML) and big data has become a powerhouse for unlocking valuable insights, fueling predictive analytics, and steering data-driven decision-making. This dynamic intersection is reshaping industries, offering unprecedented opportunities for organizations to glean actionable intelligence from massive datasets. By combining the scalability and processing capabilities of big data technologies with the intelligence of machine learning algorithms, businesses can not only analyze historical data but also predict future trends and optimize decision-making processes. This course is useful for applying the machine learning algorithms to perform various operations on big data. Moreover, this course helps to know the methodology to train the big data through ML algorithms. Even though, to manage this unstructured data is a challenging task today. However, the ML algorithms applied on big data by performing Data Segmentation, Data Analytics and Simulation. This course covers the basics of big data, the available ML technique to process, analyze and making decisions on big data.

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
CSEB04.CO1	Apply a method to leverage the big data using the steps of machine learning.
CSEB04.CO2	Apply machine learning techniques to explore and prepare data for modelling.
CSEB04.CO3	Identify the type of machine learning problem to apply the appropriate techniques.
CSEB04.CO4	Construct models that learn from data using widely available open-source tools.
CSEB04.CO5	Analyze big data problems using scalable machine learning algorithms on Spark.

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/docume nt.	**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** Use descriptive statistics for decisions making by organizing, analyzing, and visualizing large complex datasets.	**PO-5** Analyze datasets with supervised learning methods for functional approximation, classification, and forecasting and unsupervised learning methods for dimensionality reduction and clustering.	**PO-6** Manage the security and quality of data to ensure its access control and accuracy.
CSEB04.CO1	3	3	3	3	3	-
CSEB04.CO2	3	3	3	3	3	-
CSEB04.CO3	3	3	2	2	2	-
CSEB04.CO4	3	3	3	3	3	-
CSEB04.CO5	3	3	2	3	2	-

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

G)   Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
CSEB04	PCC	Machine Learning using Big Data	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 the big data integration and big data processing. TSO 1b. Differentiate the Machine Learning techniques TSO 1c. Write the procedure to scale up the Machine Learning Algorithms.	**Unit-1.0 Introduction** 1.1 Introduction to Machine Learning with Big Data 1.2 Summary of Big Data Integration and Processing 1.3 Machine Learning Overview 1.4 Categories of Machine Learning Techniques 1.5 Machine Learning Process, 1.6 Goals, and Activities in the Machine Learning Process 1.7 CRISP-DM 1.8 Scaling Up Machine Learning Algorithms	**CO1**
TSO 2a. Write the procedure to prepare a quality data. TSO 2b. Perform the feature selection on any dataset TSO 2c. Perform feature transformation on a dataset TSO 2d. Apply dimensionality reduction over the dataset. TSO 2e. Handle the missing values of any dataset in Spark and KNIME. TSO 2f. Evaluate the effectiveness of the data pre-processing by using any classifier.	**Unit-2.0 Data Preprocessing** 2.1 Data Preparation 2.2 Data Quality 2.3 Addressing Data Quality Issues 2.4 Feature Selection 2.5 Feature Transformation 2.6 Dimensionality Reduction 2.7 Handling Missing Values in KNIME 2.8 Handling Missing Values in Spark	**CO2**
TSO 3a. Develop a classification by incorporating all the steps TSO 3b. Apply K-nearest neighbors algorithm to classify the data of any dataset. TSO 3c. Differentiate the Decision Tree and Naïve Bayes TSO 3d. Apply a suitable classifier to predict the future of any real time dataset. TSO 3e. Apply suitable classifiers on KNIME and Spark. TSO 3f. Evaluate the classifiers with respect to the evaluation metrics through experiments.	**Unit-3.0 Classification** 3.1 Introduction to Classification 3.2 Building and Applying a Classification Model 3.3 Classification Algorithms 3.4 k-Nearest Neighbors 3.5 Decision Trees 3.6 Naïve Bayes 3.7 Classification using Decision Tree in KNIME, and Classification in Spark.	**CO3, CO4, & CO5**
TSO 4a. Demonstrate the Overfitting process on Decision tree TSO 4b. Prepare a confusion matrix for the decision tree on any specific dataset.	**Unit-4.0 Evaluation of ML Models** 4.1 Generalization and Overfitting 4.2 Overfitting in Decision Trees	**CO4 & CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 4c. Evaluate the performance of decision tree in KNIME and Spark on any specific dataset.	4.3 Using a Validation Set 4.4 Metrics to Evaluate Model Performance 4.5 Confusion Matrix 4.6 Evaluation of Decision Tree in KNIME 4.7 Evaluation of Decision Tree in Spark	
TSO 5a. Develop a regression tree for a specific dataset. *TSO 5b.* Apply a Linear Regression on a specific dataset *TSO 5c.* Use k-means clustering algorithm to enrich the prediction result. *TSO 5d.* Perform the cluster analysis in Spark. *TSO 5e.* Evaluate the ML models using evaluation metrics	**Unit -5.0 ML Models** 5.1 Regression 5.2 Cluster Analysis, and Association Analysis: Regression Overview, Linear Regression 5.3 Cluster Analysis- k-means Clustering 5.4 Association Analysis and in Detail 5.5 Machine Learning with Big Data 5.6 Final Remarks & Cluster Analysis in Spark	**CO4 & CO5**

J)   Suggested Laboratory experiences:

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
LSO 1.1. Apply basic data pre-processing tasks on a big data dataset. *LSO 1.2.* Evaluate the performance of the preprocessing through a classifier.	1.	Write a Python source code to apply the basic Data Pre-processing Techniques using Python on a Big data	CO1
LSO 2.1. Apply any feature selection algorithm on a big data dataset. *LSO 2.2.* Evaluate the performance of the preprocessing through a classifier.	2.	Write a Python source code to perform the feature selection process by applying dimensionality reduction on a big data dataset.	CO1
LSO 3.1. Apply feature transformation on feature selection algorithm by considering a big data dataset as input. *LSO 3.2.* Evaluate the performance of the preprocessing through a classifier.	3.	Write a Python source code to perform the feature selection process by applying feature transformation on a big data dataset.	CO1 & CO2
LSO 4.1. Apply the missing value handling methodology on a big data dataset in Spart and KNIME. *LSO 4.2.* Evaluate the performance of the missing values removed big data dataset on a specific classifier.	4.	Demonstrate the missing values handling process in KNIME and Spark by considering any big data dataset.	CO1 & CO2
LSO 5.1. Implement the k-NN classifier on big data dataset.	5.	Implement the k-NN algorithm on a big data dataset in Spark. Evaluate the performance of k-NN in terms of effectiveness and efficiency.	CO1 & CO2

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
LSO 5.2. Evaluate the performance of k-NN with respect to the evaluation metrics.			
LSO 6.1. Implement the Naïve Bayes classifier on big data dataset. *LSO 6.2.* Evaluate the performance of Naïve Bayes with respect to the evaluation metrics.	6.	Implement the Naïve Bayes algorithm on a big data dataset in Spark. Evaluate the performance of Naïve Bayes in terms of effectiveness and efficiency.	CO3
LSO 7.1. Implement the Decision Tree classifier on big data dataset *LSO 7.2.* Evaluate the performance of Decision Tree with respect to the evaluation metrics.	7.	Implement the Decision Tree algorithm on a big data dataset in Spark. Evaluate the performance of decision tree in terms of effectiveness and efficiency.	CO4 & CO5
LSO 8.1. Implement the Overfitting process on decision tree. *LSO 8.2.* Evaluate the performance of the Overfitting incorporated decision tree in Spark and KNIME with respect to the evaluation metrics.	8.	Demonstrate the evaluation of decision tree by considering the Overfitting in Spark and KNIME.	CO4 & CO5
LSO 9.1. Implement the Linear Regression classifier on big data dataset. *LSO 9.2.* Evaluate the performance of Linear Regression with respect to the evaluation metrics.	9.	Implement the Linear Regression algorithm on a big data dataset in Spark. Evaluate the performance of Linear Regression in terms of effectiveness and efficiency.	CO4 & CO5
LSO 10.1. Implement the k-means clustering algorithm on big data dataset. *LSO 10.2.* Evaluate the performance of k-Means clustering with respect to the evaluation metrics.	10.	Implement the k-means clustering algorithm on a big data dataset in Spark. Evaluate the performance of k-means clustering in terms of effectiveness and efficiency.	CO4 & CO5

K) Suggested Research Based Problems

i.   The analysis of big data provides various benefits towards developing a prediction system. For this purpose, this research work proposes a new machine learning-based big data analytics model to predict the multi-diseases to supply a better decision for the different healthcare applications. The proposed healthcare framework consists of the following classifiers:

- Principal Component Analysis (PCA)
- Butterfly Optimization Algorithm (BOA)
- Fuzzy Artificial Neural Network (FANN)

ii. Here, the PCA is used to extract the relevant features from the dataset and BOA is helpful for optimizing the number of features. Then, the FANN is used to predict the disease by performing the classification process.   This framework needs to be evaluated by conducting experiments based on the standard evaluation metrics such as precision, recall, f-measure and accuracy.

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iii.   Real-time and accurate prediction of terminal area arrival traffic flow is a key issue for terminal area traffic management. In this research work, the static and dynamic prediction models have been analysed in detail by considering the merits and demerits towards airspace prediction. Based on the analysis report, a new airspace prediction framework has been designed by considering the machine learning algorithms for predicting the number of aircraft arrival. Here, the ADS-B data has been collected from the terminal area of Chengdu is used to study the prediction accuracy based on different machine learning algorithms including Decision Tree, Naïve Bayes and k-NN in the proposed framework. Experimental results of the framework show the prediction accuracy and efficiency.

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:

- Overview of Big data
- Role of Big data in Emerging Applications
- ML algorithms in Big data processing
- ML algorithms in the development of Emerging Areas
- Comparative ML algorithms on Big data processing

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	11
CO2	Unit 2.0 Data preprocessing	14
CO3	Unit 3.0 Classification	15
CO4	Unit 4.0 Evaluation of ML models	15
CO5	Unit 5.0 ML Models	15
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 i5, 4 GB RAM, 15 GB free disk space	All
2.	Anaconda with Jupiter Notebook	Anaconda 3.1 Version	All

P) **Suggested Learning Resources:**

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Hands-On Machine Learning with Scikit-Learn, Keras, and Tensor Flow: Concepts, Tools, and Techniques to Build Intelligent Systems	Aurélien Géron	2nd Edition, ISBN-13: 978-1492032649, ISBN-10: 1492032646
2.	Hands-on Scikit-Learn for Machine Learning Applications: Data Science Fundamentals with Python	David Paper Logan	UT, USA ISBN-13 (pbk): 978-1-4842-5372-4 ISBN-13 (electronic): 978-1-4842-5373-1
3.	Understanding Big data	Chris Eaton, Dirk deroos et al	McGraw Hill, 2012.

b) Online Educational Resources (OER):

1)   http://www.digimat.in/nptel/courses/video/106104189/L01.html
2)   https://onlinecourses.nptel.ac.in/noc19_cs82/preview
3)   https://vitalflux.com/machine-learning-nptel-courses-list-2023/
4)   https://www.javatpoint.com/machine-learning
5)   https://www.w3schools.com/ai/ai_data.asp
6)   https://www.w3schools.in/hadoop/what-is-big-data

Q) **Course Curriculum Developer**

S. No.	Name	E-mail Address
1.	Prof. S. Ganapathy	sganapathy@nitttrbpl.ac.in

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A)	**Course Title:** Basics of Artificial Intelligence and Machine Learning
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	**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)
exception handling in Python *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**

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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 4.1.	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. LSO 7.2.	Visualize the given data in various dimensions. 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

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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

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Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant CO Number (s)
LSO 14.1 Visualize the given dataset using the Weka Tool. *LSO 14.2* Visualize the given dataset using the Orange3 Tool. *LSO 14.3* Visualize the given dataset using the Julia AI tool.	14.	a) Perform the data visualization using the Weka Tool. b) Perform the data visualization using the Orange3 Tool. c) Perform the data visualization using the Julia AI tool.	CO5, CO6
LSO 15.1 Preprocess the given dataset using the Weka Tool. *LSO 15.2* Preprocess the given dataset using the Orange3 Tool. *LSO 15.3* Preprocess the given dataset using the Julia AI tool.	15.	a) Perform the data preprocessing on the given dataset using the Weka Tool. b) Perform the data preprocessing on the given dataset using the Orange3 Tool. c) Perform the data preprocessing on the given dataset using the Julia AI tool.	CO5, CO6
LSO 16.1 Classify the given dataset using the Weka Tool. *LSO 16.2* Classify the given dataset using the Orange3 Tool. *LSO 16.3* Classify the given dataset using the Julia AI tool.	16.	a) Perform the classification process on the given dataset using the Weka Tool. b) Perform the classification process using the Orange3 Tool. c) Perform the classification process using the Julia AI tool	CO5, CO6

K)   Suggested Research Based Problems

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

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

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

L)   Suggested Term Work (TW):

a.   Assignment(s):

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

b. **Seminar Topics:**

- Python Libraries and Packages used in data analytics
- Comparison of various Data Visualization tools
- Role of predictive analysis in real-time applications
- ML algorithms in Decision Making
- ML algorithms in feature engineering
- Weka Vs Orange3 Vs Julia AI
- Role of AI and ML in Multidisciplinary Research

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

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

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

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experience /Practical Number
1.	Computer system	Processor Intel Core i7, 32 GB RAM, 15 GB free disk space	All
2.	Integrated Development and Learning Environment (IDLE)	S/w to be downloaded for Python 3.11.3 or higher	1-13
3.	Anaconda Navigator / Jupyter NoteBook	Server for Software Platform	1-13
4.	Weka	Software Tool	14,15 & 16
5.	Orange3	Software Tool	14,15 & 16
6.	Julia AI	Software Tool	14,15 & 16

P)   Suggested Learning Resources:

a) Books

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

b) Online Educational Resources (OER):

1)   https://docs.python.org/3/tutorial/
2)   https://nptel.ac.in/courses/106106145
3)   https://www.w3schools.com/python/
4)   https://www.tutorialspoint.com/python/index.htm
5)   https://www.w3schools.com/python/pandas/default.asp
6)   https://pandas.pydata.org/docs/user_guide/10min.html

7)   http://bedford-computing.co.uk/learning/wp-content/uploads/2015/10/Python-Cookbook-3rd-Edition.pdf

8)   Data Sources:
- https://archive.ics.uci.edu/ml/machine-learning-databases/auto-mpg/
- https://archive.ics.uci.edu/ml/machine-learning-databases/iris/iris.data
- https://www.kaggle.com/arshid/iris-flower-dataset
- https://www.kaggle.com/rohankayan/years-of-experience-and-salary-dataset
- https://www.kaggle.com/datasets/johnsmith88/heart-disease-dataset
- https://www.kaggle.com/datasets/harunshimanto/epileptic-seizure-recognition
- https://www.kaggle.com/datasets/mathchi/diabetes-data-set

Q)   Course Curriculum Development Team

S. No.	Name	E-mail Address
1.	Prof. S. Ganapathy	sganapathy@nitttrbpl.ac.in
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A)	**Course Title:** Sports, Yoga & Meditation	
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	**CO2**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
	2.12 Adaptation of yoga and meditations for physically challenged students in all levels	
TSO 3a. Describe the mental aspects of sports and performance. *TSO 3b.* Apply skills learned in sports, yoga, 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.	**Unit-3.0 Sports, Mental Conditioning and Integration** 3.1 Mental preparation techniques for sports 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	**CO3**

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

S. No.	Name of Equipment, Tools and Software	Broad Specifications
12.	Chess, carrom	Chess and carrom set
13.	Resistance Bands	Various resistance levels, latex material
14.	Dumbbells	1-10 lbs, adjustable weights
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

S. No.	Name of Equipment, Tools and Software	Broad Specifications
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
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)

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
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)	
B)	**Course Code:** NEP02	
C)	**Pre- requisite (s):**	

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

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

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

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

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

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

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

G) **Teaching & Learning and Assessment Scheme:**

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

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

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

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

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

J)   Suggested Laboratory Experiences: (Not Applicable)

K)   Suggested Research Based Problems

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

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

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

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

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

L)   Suggested Term Work (TW):

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

    b.   Seminar Topics:

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

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

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

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

P)   **Suggested Learning Resources:**

   a) Books

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

   b) Online Educational Resources (OER):

   1)   OER for Empowering Teachers Instructional Material by P. Malliga is licensed under a Creative Commons Attribution 4.0 International License.

   2)   William & Flore Hewlett Foundation. (n.d.). OER defined. Retrieved from https://hewlett.org/strategy/open-educational-resources/

   3)   Free Software Foundation. (2008). GNU Free Documentation License. Retrieved from https://www.gnu.org/licenses/fdl.html

   4)   Copyleft Attitude. (2007). Free Art License 1.3. Retrieved from http://artlibre.org/licence/lal/en/

   5)   Free Software Foundation. (n.d.). What is copyleft? Retrieved from https://www.gnu.org/copyleft/copyleft.html

Q)   **Course Curriculum Development Team**

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A)	**Course Title:** Professional Ethics
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: G**roup 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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National Institute of Technical Teachers' Training and Research, Bhopal
(Deemed to be University under Distinct Category), MOE, GOI

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A)	**Course Title:** Financial Literacy	
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.	**Unit-1.0: Basic Financial Concepts**	**CO1, CO2**
TSO 1b. Explain Income/ Expenses/ Net Worth for the given situation.	1.1 Personal Financial Goals 1.2 Income, Expenses, and Net Worth	

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

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

J)   **Suggested Laboratory Experiences:** (Not Applicable)

K)   **Suggested Research Based Problems**

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

L)   **Suggested Term Work (TW):**

     a.   **Assignment(s):**

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

     b.   **Visits:**

- Arrange a visit to a tax filing consultancy nearby.

     c.   **Group discussions on current print articles.**

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

     d.   **Self-learning topics:**

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

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

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

f. **Seminar Topics:**

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

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

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

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

P) **Suggested Learning Resources:**
a) **Books**

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

b) Online Educational Resources (OER):

1) https://www.investopedia.com/guide-to-financial-literacy-4800530#:~:text=Financial%20literacy%20is%20the%20ability%20to%20understand%20and,money%2C%20compound%20interest%2C%20managing%20debt%2C%20and%20financial%20planning.

2) https://www.fidelity.com/learning-center/smart-money/financial-literacy

3) https://www.forbes.com/sites/truetamplin/2023/09/21/financial-literacy--meaning-components-benefits--strategies/

4) https://yourstory.com/2023/07/financial-literacy-is-key-to-unlocking-india-economy

5) https://www.investopedia.com/financial-literacy-5224001

Q)   Course Curriculum Developer

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A)	**Course Title:** Engineering Economics
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	Theory Component (TC) Input (I)	Theory Component (TC) Tutorial (T)	Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	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)	Total Marks (TA+TWA+LA)
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,	**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	CO2

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
internal rate of return method, Cost-benefit analysis for the given product *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	method, Net present value method, 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.

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- 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

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A)	**Course Title:** Information Retrieval Techniques
B)	**Course Code:** CSEB06
C)	**Pre-requisite (s):**

D)   **Rationale:** An Information Retrieval (IR) system is a software program that deals with the organization, storage, retrieval, and evaluation of information from document repositories that includes structured and unstructured data. Users need to know effective techniques and strategies to get proper and exact information from repositories. Retrieval techniques are designed to help users to locate the information they need effectively and efficiently. Information retrieval is widely used in various domains, such as academia, healthcare, finance, and research. It plays a crucial role in powering search engines, recommendation systems, question-answering systems, and personalized information delivery platforms. By discovering associations and understanding patterns and trends within the data, data analytics has the potential to improve retrieval efficiency and lower costs. Thus, data analytics applications in information retrieval can take advantage of the deep exploration of data to extract insights for making better-informed decisions.

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
CSEB06.CO1	Analyze the Software architecture of the IR system
CSEB06.CO2	Implement a suitable Information retrieval model based on the application
CSEB06.CO3	Apply machine learning techniques for text classification and clustering
CSEB06.CO4	Design and implement innovative features in a search engine
CSEB06.CO5	Design and implement a recommender system.

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/docume nt.	**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** Use descriptive statistics for decisions making by organizing, analyzing, and visualizing large complex datasets.	**PO-5** Analyze datasets with supervised learning methods for functional approximation, classification, and forecasting and unsupervised learning methods for dimensionality reduction and clustering.	**PO-6** Manage the security and quality of data to ensure its access control and accuracy.
CSEB06.CO1	2	3	2	-	2	-
CSEB06.CO2	2	3	2	2	2	-
CSEB06.CO3	3	3	2	3	3	-
CSEB06.CO4	2	3	3	3	-	2
CSEB06.CO5	2	3	2	2	2	-

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

G) Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
CSEB06	PCC	Information Retrieval Techniques	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, 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 IR Problems and Issues. *TSO 1b.* Differentiate Data and information retrieval. *TSO 1c.* Illustrate Software Architecture of the IR System. *TSO 1d.* Describe Practical Issues on the Web *TSO 1e.* Describe current search practices by considering the search interfaces	**Unit-1.0 Introduction to Information Retrieval System** 1.1 Information Retrieval (IR), Evolution, Early Developments, the IR Problems and Issues 1.2 The User 's Task, Information versus Data Retrieval. 1.3 The IR System, The Software Architecture of the IR System, The Retrieval and Ranking Processes 1.4 The Web, The e-Publishing Era, Practical Issues on the Web 1.5 Search Practices, Current Search Interfaces, Visualization in Search Interfaces	**CO1**
TSO 2a. Compare the working of various IR Models *TSO 2b.* Evaluate the performance of different IR models on various parameters. *TSO 2c.* Apply Relevance Feedback and Query expansion to Improve the quality of search results.	**Unit-2.0 Modeling and Retrieval Evaluation** 2.1 Information retrieval techniques 2.2 Basic IR Models- Boolean Model, TF-IDF (Term Frequency/Inverse Document Frequency) Weighting, Vector Space Model, Probabilistic Model, Latent Semantic Indexing Model, Neural Network Model. 2.3 Retrieval Evaluation, Retrieval Metrics, Precision and Recall 2.4 Reference Collection, User-based Evaluation, Relevance Feedback and Query Formulation and Expansion, Explicit Relevance Feedback	**CO2**
TSO 3a. Apply the appropriate method of classification and clustering *TSO 3b.* Reduce the number of features in a dataset to improve search results. *TSO 3c.* Use indexing to Improve the efficiency of search results by speeding the search	**Unit-3.0 Text Classification and Clustering** 3.1 Characterization of Text Classification, Unsupervised Algorithms: Clustering, Naïve Text Classification, Supervised Algorithms, Decision Tree, k-NN Classifier, SVM Classifier, neural classifiers 3.2 Feature Selection or Dimensionality Reduction –Evaluation Metrics–Accuracy and Error 3.3 Organizing the classes – Indexing and Searching – Inverted Indexes – Sequential Searching –Multi-dimensional Indexing.	**CO3**
TSO 4a. Illustrate different search engine architectures	**Unit-4.0 Information Retrieval and Web Crawling**	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 4b. Implement PageRank technique *TSO 4c.* Develop a basic search engine	4.1 The Web Search Engine Architectures, Cluster based Architecture, Distributed Architectures 4.2 Search Engine Ranking, Link-based Ranking, Simple Ranking Functions, Static and Dynamic Ranking, Learning to Rank, Evaluations 4.3 Search Engine User Interaction, Link Analysis: PageRank and HITS, Browsing, Query logs analysis, personalization, and recommendations 4.4 Web Crawling Techniques, Applications of a Web Crawler, Taxonomy, Architecture and Implementation, Scheduling Algorithms, Evaluation	
TSO 5a. Explain the functioning of various Recommendation Techniques *TSO 5b.* Compare the working of different filtering models of the recommender system	**Unit -5.0: Recommender System** 5.1 Sentiment analysis, semantic analysis 5.2 Recommender Systems Functions, Data and Knowledge Sources, Recommendation Techniques, Basics of Content-based Recommender Systems, High-Level Architecture. 5.3 Advantages and Drawbacks of Content-based Filtering, Collaborative Filtering, Matrix factorisation models, Neighbourhood models.	CO5

J)   Suggested Laboratory Experiences: (Not Applicable)

K)   Suggested Research Based Problems

    i.   Implement a Probabilistic Models/ VSM-based retrieval system.

    ii. E-learners are struggling to get suitable content to learn technical courses in online mode. To help the e-learners, you need to develop a new content recommendation system to recommend the suitable content to the different level of learners who are learning the software engineering course through online. The system need to recommend the different level of contents like tough, moderate and easy. Incorporate the tasks like preprocessing, semantic analysis, classification using the following algorithms

- ID3
- SVM
- Quantum SVM

Identify the best classifier based on the performance in terms of classification accuracy.

Finalize the content recommendation system and prove that it is useful.

iii.   Implement a query expansion module with relevance feedback
iv.   Develop a basic web crawler and implement PageRank

- Principal Component Analysis (PCA)
- MLP
- Artificial Neural Network (ANN)

Identify the best classifier based on the performance in terms of detection accuracy.

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:

- Comparative study of web crawling and link analysis tools
- Role of Natural Language Processing (NLP) in Information Retrieval
- Content-based image retrieval (CBIR) techniques
- Query Expansion Techniques in Information Retrieval
- Machine translation in search engines

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 Information Retrieval System	10
CO2	Unit -2.0 Modeling and Retrieval Evaluation	16
CO3	Unit -3.0 Text Classification and Clustering	16
CO4	Unit -4.0 Web Retrieval and Web Crawling	14
CO5	Unit -5.0 Recommender System	14
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 i5, 8 GB RAM, 100 GB free disk space	For Research based problem(s)
2.	Software tools and resources	• Python and libraries: NLTK, Scikit-learn, Gensim, PyTorch, TensorFlow • ElasticSearch or Apache Solr for large-scale IR systems • Web scraping and crawling tools like Scrapy	For Research based problem(s)

P) **Suggested Learning Resources:**

a) **Books**

S. No.	Titles	Author(s)	Publisher and Edition withISBN
1.	Introduction to Information Retrieval	Christopher D. Manning, Prabhakar Raghavan, and Hinrich Schütze	Cambridge University Press; Illustrated ISBN-10: 0521865719 ISBN-13: 978-0521865715
2.	Modern Information Retrieval: The Concepts	Ricardo Baeza-Yates and Berthier Ribeiro-Neto	Addison-Wesley Educational Publishers Inc, ISBN-10: 0321416910 ISBN-13: 978-0321416919
3.	Information Retrieval: Implementing and Evaluating Search Engines	Stefan Buettcher, Charles L. A. Clarke and Gordon V. Cormack	The MIT Press, ISBN-10: 0262026511 ISBN-13: 978-0262026512
4.	Search Engines: Information Retrieval in Practice	W. Bruce Croft, Donald Metzler, and Trevor Strohman	Pearson, ISBN-10: 0136072240 ISBN-13: 978-0136072249

b) **Online Educational Resources (OER):**

1) https://www.tutorialspoint.com/natural_language_processing/natural_language_processing_information_retrieval.htm
2) https://www.geeksforgeeks.org/what-is-information-retrieval/
3) https://www.coursera.org/courses?query=information%20retrieval
4) https://marketbrew.ai/a/information-retrieval-seo

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

Q)   Course Curriculum Development Team

S. No.	Name	E-mail Address
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A)	**Course Title:** Data Governance and Security
B)	**Course Code:** CSEB07
C)	**Pre- requisite (s):** A foundational knowledge of big data technologies (e.g., Hadoop, Spark), data governance frameworks, and cybersecurity principles. Familiarity with compliance regulations and access control mechanisms is also required.

D) **Rationale:** With the exponential growth of data, ensuring proper governance and security in big data environments has become critical. Effective data governance ensures the accuracy, accessibility, and consistency of data, while security measures protect sensitive information from breaches and unauthorized access. As organizations increasingly rely on data-driven decision-making, robust governance and security frameworks are essential to maintain compliance with legal regulations (such as GDPR and HIPAA), foster trust, and mitigate risks. By establishing clear policies and controls, organizations can maximize the value of their data while minimizing vulnerabilities and ensuring long-term sustainability in a digital ecosystem.

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
CSEB07.CO1	Design a metadata management system with necessary components of suitable data governance framework for real world applications.
CSEB07.CO2	Design conceptual and logical enterprise data models and catalog.
CSEB07.CO3	Create conceptual and logical enterprise data models for various scenarios.
CSEB07.CO4	Measure data quality using data quality scores and thresholds.
CSEB07.CO5	Apply data governance processes for authoring, monitoring, and approval of master data.

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/docume nt.	**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** Use descriptive statistics for decisions making by organizing, analyzing, and visualizing large complex datasets.	**PO-5** Analyze datasets with supervised learning methods for functional approximation, classification, and forecasting and unsupervised learning methods for dimensionality reduction and clustering.	**PO-6** Manage the security and quality of data to ensure its access control and accuracy.
CSEB07.CO1	2	3	3	2	3	-
CSEB07.CO2	2	3	3	3	2	-
CSEB07.CO3	3	3	3	3	3	-
CSEB07.CO4	2	3	2	2	2	-
CSEB07.CO5	3	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)	
CSEB07	PCC	Data Governance and Security	30	15	-	45	90	03	30	70	20	-	-	-	120

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

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I)   Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Explain the Metadata and Its Role in Data Management TSO 1b. Explain the Core Concepts of Data Governance Frameworks: Accountability, Stewardship, and Compliance TSO 1c. Explain the Metadata Types: Technical, Business, and Operational TSO 1d. What is use of Metadata Lifecycle: Capture, Storage, Usage, and Maintenance TSO 1e. Apply Case Studies on Metadata Management Systems in Real-World Applications	**Unit-1.0 Fundamentals of Metadata Management and Data Governance** 1.2 Introduction to Metadata and Its Role in Data Management 1.3 Core Concepts of Data Governance Frameworks: Accountability, Stewardship, and Compliance 1.4 Metadata Types: Technical, Business, and Operational 1.5 Metadata Lifecycle: Capture, Storage, Usage, and Maintenance 1.6 Case Studies on Metadata Management Systems in Real-World Applications	**CO1**
TSO 2a. Designing Conceptual and Logical Data Models TSO 2b. Explain Role of Data Models in Enterprise Architecture TSO 2c. Explain Tools and Techniques for Data Cataloging TSO 2d. What are the Best Practices for Creating and Maintaining Enterprise Data Catalogs TSO 2e. Use Real-World Examples of Data Models from Various Domains	**Unit-2.0 Enterprise Data Models and Data Cataloging** 2.1 Designing Conceptual and Logical Data Models: Overview and Principles 2.2 Role of Data Models in Enterprise Architecture 2.3 Tools and Techniques for Data Cataloging 2.4 Best Practices for Creating and Maintaining Enterprise Data Catalogs 2.5 Real-World Examples of Data Models from Various Domains (e.g., Healthcare, Finance)	**CO2**
TSO 3a. Use the Conceptual Data Modeling: Capturing Business Requirements TSO 3b. Creating Detailed Structures for Data Storage TSO 3c. Use of Data Modeling in Different Contexts: Transactional, Analytical, and Hybrid Systems. TSO 3d. Use of Data Modeling for Specific Industry Scenarios: Retail, Banking, E-commerce, and Healthcare. TSO 3e. Apply Case Studies and Practical Assignments on Designing Data Models for Real-World Scenarios	**Unit-3.0 Advanced Data Modeling Techniques for Various Scenarios** 3.1 Conceptual Data Modeling: Capturing Business Requirements\ 3.2 Logical Data Modeling: Creating Detailed Structures for Data Storage 3.3 Data Modeling in Different Contexts: Transactional, Analytical, and Hybrid Systems 3.4 Data Modeling for Specific Industry Scenarios: Retail, Banking, E-commerce, and Healthcare 3.5 Case Studies and Practical Assignments on Designing Data Models for Real-World Scenarios	**CO2, CO3**
TSO 4a. Explain Data Quality: Dimensions and Challenges	**Unit-4.0 Data Quality Management and Assessment**	**CO3, CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 4b. Explain Completeness, Accuracy, Consistency, Timeliness in Metrics for Measuring Data Quality *TSO 4c.* Explain Data Quality Scores *TSO 4d.* Explain Establishing Tolerances for Business. *TSO 4e.* Explain Tools and Technologies for Data Quality Monitoring and Reporting *TSO 4f.* Use of Real-World Case Studies of Data Quality Initiatives in Big Data Environments	4.1 Defining Data Quality: Dimensions and Challenges 4.2 Metrics for Measuring Data Quality: Completeness, Accuracy, Consistency, Timeliness 4.3 Data Quality Scores: How to Calculate and Use Them 4.4 Data Quality Thresholds: Establishing Tolerances for Business Use 4.5 Tools and Technologies for Data Quality Monitoring and Reporting 4.6 Real-World Case Studies of Data Quality Initiatives in Big Data Environments	
TSO 5a. Explain Master Data Management (MDM) and Its Importance in Data Governance *TSO 5b.* Use of Governance Processes for Master Data: Creation, Authoring, Monitoring, and Approval *TSO 5c.* Explain Role of Data Stewards and Data Custodians in Governance *TSO 5d.* Explain the working Implementing Data Governance Policies and Procedures *TSO 5e.* What is the use of Data Governance Maturity Models and Assessment	**Unit -5.0 Master Data Management (MDM) and Data Governance Processes** 5.1 Introduction to Master Data Management (MDM) and Its Importance in Data Governance 5.2 Governance Processes for Master Data: Creation, Authoring, Monitoring, and Approval 5.3 Role of Data Stewards and Data Custodians in Governance 5.4 Implementing Data Governance Policies and Procedures 5.5 Governance Frameworks: Data Governance Maturity Models and Assessment 5.6 Hands-on Projects: Implementing MDM and Governance Processes in an Enterprise Context	**CO4, CO5**

J)   Suggested Laboratory Experiences: (Not Applicable)

K)   Suggested Research Based Problems:

   i.   **Title:** Optimizing Metadata Management for Distributed Cloud Data Systems

   Description: Investigate how to design a scalable metadata management system that can efficiently handle metadata in distributed cloud environments (e.g., AWS, Azure, GCP). The research should focus on ensuring high availability, data consistency, and compliance with data governance frameworks such as GDPR, HIPAA, or industry-specific regulations.

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ii.   **Title:** Automated Governance for Master Data Management in Global Supply Chains

Description: Investigate the application of automated data governance processes for authoring, monitoring, and approving master data in large-scale, globally distributed supply chain networks. The research should explore how automation can enhance the accuracy, transparency, and timeliness of master data management while ensuring compliance with local and international regulations.

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:**

- Implementing Effective Metadata Management Systems: Challenges and Solutions
- Data Governance Frameworks: Ensuring Data Integrity and Compliance in Big Data
- Enterprise Data Modeling: Best Practices and Tools for Data Cataloging
- Measuring and Improving Data Quality: Techniques and Real-World Applications
- Data Lineage and Its Role in Data Governance for Regulatory Compliance
- The Impact of Artificial Intelligence on Metadata Management and Data Governance
- Automating Data Governance Processes: Tools and Technologies
- Data Governance in Healthcare: Ensuring Compliance with HIPAA and Other Regulations
- The Role of Blockchain in Enhancing Data Governance and Security

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

COs	Relevant Unit Number and Title	Marks
CO1	Unit 1.0 Fundamentals of Metadata Management and Data Governance	11
CO2	Unit 2.0 Enterprise Data Models and Data Cataloging	14
CO3	Unit 3.0 Advanced Data Modeling Techniques for Various Scenarios	15
CO4	Unit 4.0 Data Quality Management and Assessment	15
CO5	Unit 5.0 Master Data Management (MDM) and Data Governance Processes	15
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:** (Not Applicable)

P) **Suggested Learning Resources:**

   a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Data Governance: How to Design, Deploy, and Sustain an Effective Data Governance Program	Data Governance: How to Design, Deploy, and Sustain an Effective Data Governance Program	Data Governance: How to Design, Deploy, and Sustain an Effective Data Governance Program
2.	Data Modeling Made Simple: A Practical Guide for Business & IT Professionals	Data Modeling Made Simple: A Practical Guide for Business & IT Professionals	Data Modeling Made Simple: A Practical Guide for Business & IT Professionals
3.	Data Management for Researchers: Organize, Maintain and Share Your Data for Research Success	Data Management for Researchers: Organize, Maintain and Share Your Data for Research Success	Data Management for Researchers: Organize, Maintain and Share Your Data for Research Success
4.	Mastering Data Modeling: A User-Driven Approach	Mastering Data Modeling: A User-Driven Approach	Mastering Data Modeling: A User-Driven Approach
5.	Master Data Management and Data Governance	Master Data Management and Data Governance	Master Data Management and Data Governance
6.	Data Governance: Creating Value from Information Assets	Data Governance: Creating Value from Information Assets	Data Governance: Creating Value from Information Assets

   b) Online Educational Resources (OER):

   1) https://www.coursera.org/learn/big-data-management
   2) https://www.coursera.org/courses?query=data%20governance
   3) https://www.edx.org/learn/data-management
   4) https://www.youtube.com/channel/UCObs0kLIrDjX2LLSybqNaEA
   5) https://www.youtube.com/channel/UCsvqVGtbbyHaMoevxPAq9Fg

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6)   Data Source:

- https://archive.ics.uci.edu/
- https://data.gov/
- https://github.com/joke2k/faker
- https://sdv.dev/
- https://data.nasdaq.com/institutional-investors

Q)   Course Curriculum Developer

S. No.	Name	E-mail Address
1.	Prof. S. Ganapathy	sganapathy@nitttrbpl.ac.in

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A)	**Course Title:** Big Data Tools
B)	**Course Code:** CSEB08
C)	**Pre- requisite (s):** Should have knowledge of one Programming Language (Java preferably), Practice of SQL (queries and sub queries), exposure to Linux Environment.

D)   Rationale: Big data tools are essential for handling the immense volume, variety, velocity, and veracity of data generated in today's digital age. They enable organizations to efficiently process and analyze diverse data types in real-time or near-real-time, ensuring the reliability of insights derived from the data. By leveraging distributed computing, machine learning, and other advanced analytics techniques, big data tools empower organizations to extract actionable insights, drive better decision-making, and uncover new business opportunities. Moreover, these tools offer cost-effective scalability, allowing organizations to seamlessly expand their data infrastructure as data volumes continue to grow. Ultimately, the rationale behind big data tools lies in their capacity to unlock the value hidden within large datasets, driving innovation and competitiveness in the data-driven economy.

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
CSEB08.CO1	Use Big Data and its Business Implications.
CSEB08.CO2	Implement Data on Distributed File System
CSEB08.CO3	Apply Job Execution in Hadoop Environment
CSEB08.CO4	Develop Big Data Solutions using Hadoop Eco System
CSEB08.CO5	Analyze Infosphere Big Insights Big Data Recommendations.
CSEB08.CO6	Use various bigdata tools with real time dataset.

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/docume nt.	**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** Use descriptive statistics for decisions making by organizing, analyzing, and visualizing large complex datasets.	**PO-5** Analyze datasets with supervised learning methods for functional approximation, classification, and forecasting and unsupervised learning methods for dimensionality reduction and clustering.	**PO-6** Manage the security and quality of data to ensure its access control and accuracy.
CSEB08.CO1	3	3	2	2	3	-
CSEB08.CO2	3	3	3	3	3	-
CSEB08.CO3	3	3	3	2	2	-
CSEB08.CO4	3	3	3	3	3	-
CSEB08.CO5	3	3	2	2	2	-
CSEB08.CO6	3	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)	
CSEB08	PEC	Big Data Tools	30	15	30	45	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, 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 different types of digital data. TSO 1b. Explain Big Data and Big Data Analytics. TSO 1c. Explain Hadoop, Apache Hadoop. TSO 1d. Use the Hadoop for analyzing streaming data. TSO 1e. Explain Hadoop echo system and big data strategy. TSO 1f. Use Infosphere Big Insights and Big Sheets.	**Unit-1.0 Introduction to Complex Networks and Graph Theoretic Metrics** 1.1 Types of Digital Data, Introduction to Big Data, Big Data Analytics. 1.2 History of Hadoop, Apache Hadoop, Analysing Data with Unix tools. 1.3 Analysing Data with Hadoop, Hadoop Streaming. 1.4 Hadoop Echo System, IBM Big Data Strategy. 1.5 Introduction to Infosphere BigInsights and Big Sheets.	**CO1**
TSO 2a. Use HDFS concepts on dataset. TSO 2b. Perform various operations on using Command Line Interface, Hadoop file system interfaces. TSO 2c. Perform various operations Data flow, Data Ingest with Flume and Scoop and Hadoop archives TSO 2d. Perform various operations on Compression, Serialization, Avro and File-Based Data structures.	**Unit-2.0 HDFS (Hadoop Distributed File System** 2.1 The Design of HDFS, HDFS Concepts. 2.2 Command Line Interface, Hadoop file system interfaces, 2.3 Data flow, Data Ingest with Flume and Scoop and Hadoop archives, 2.4 Hadoop I/O: Compression, Serialization, Avro and File-Based Data structures.	**CO2**
TSO 3a. Use the MapReduce framework, job execution flow, data partitioning, failure handling, optimization techniques in real-world applications by MapReduce job run. TSO 3b. Use the handling of failures, job scheduling, shuffle and sort process, and task execution by MapReduce job run. TSO 3c. Use different MapReduce types and formats in MapReduce framework.	**Unit-3.0 Map Reduce** 3.1 Anatomy of a Map Reduce Job Run, Failures. 3.2 Failures, Job Scheduling, Shuffle and Sort, Task Execution, 3.3 Map Reduce Types and Formats, Map Reduce Features.	**CO1, CO2, CO3**
TSO 4a. Explain Apache Pig and its execution modes. TSO 4b. Compare Pig's capabilities and use cases with traditional databases. TSO 4c. Explore the Grunt shell, Pig Latin scripting language. TSO 4d. Use User-defined functions (UDFs), and data processing operators in Apache Pig. TSO 4e. Implement given type of inheritance in Python.	**Unit-4.0 Hadoop Eco System** 4.1 Introduction to PIG, Execution Modes of Pig, Comparison of Pig with Databases 4.2 Grunt, Pig Latin, User Defined Functions, Data Processing operators. 4.3 Hive Shell, Hive Services, Hive Metastore, Comparison with Traditional Databases 4.4 HiveQL, Tables, Querying Data and User Defined Functions.	**CO3, CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 4f.　Use the Hive shell, Hive services, Hive Metastore. TSO 4g.　Explain, how Hive compares with traditional databases. TSO 4h.　Use HiveQL, table creation and management, querying data. TSO 4i.　Implementing user-defined functions (UDFs) in Hive. TSO 4j.　Explain the basics, core concepts, and clients of HBase, TSO 4k.　Use HBase and traditional RDBMS in python on dataset.	4.5　HBasics, Concepts, Clients, Example, Hbase Versus RDBMS.	
TSO 5a.　Explain machine learning and it types. TSO 5b.　Write Python programs for supervised machine learning algorithms in Python. TSO 5c.　Write Python programs for Unsupervised machine learning algorithms in Python. TSO 5d.　Use big data analytics using BigR. TSO 5e.　Use integration of big data analytics using BigR. TSO 5f.　Use its application in processing and analyzing large-scale data.	**Unit -5.0 Data Analytics with R** 5.1 Machine Learning: Introduction, Supervised Learning, Unsupervised Learning, Collaborative Filtering. 5.2 Big Data Analytics with BigR.	**CO2, CO3, CO5**

J)　　Suggested Laboratory Experiences:

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant COs Number (s)
LSO 1.1.　Write and execute and Map Reduce programe on sample large dataset.	1.	Implement a MapReduce job to process and analyze a large dataset.	CO1
LSO 2.1.　Write and execute Hadoop Streaming job using custom script to process data.	2.	Implement Hadoop Streaming job using a custom script to process data.	CO1
LSO 3.1.　Use Big Insights and Big Sheets for comparing results with Hadoop and Unix tools.	3.	Set up and analyze data using IBM Big Insights and Big Sheets, comparing results with Hadoop and Unix tools.	CO1, CO2
LSO 4.1.　Create Hadoop cluster in java and managing files in HDFS	4.	Set up a small Hadoop cluster and Create and manage files and directories within HDFS.	CO1, CO2
LSO 5.1 Code using command line tools and perform different operations.	5.	Use HDFS command line tools to perform file operations such as uploading, downloading, and managing data and Compare in Hadoop file system.	CO1, CO2

Lab Session Outcomes (LSOs)		S. No.	Laboratory Experiment Titles	Relevant COs Number (s)
LSO 6.1.	Use java to perform data ingestion pipelines using Flume and Sqoop to transfer data from external sources into HDFS.	6.	Implement data ingestion pipelines using Flume and Sqoop to transfer data from external sources into HDFS.	CO1, CO2
LSO 7.1.	Use java to perform MapReduce using job logs file.	7.	Use job logs and Implement MapReduce and compare its impact of various types of failures.	CO2, CO3
LSO 8.1.	Use java to perform MapReduce using complex data shuffling and sorting.	8.	Implement complex data shuffling and sorting using MapReduce and Measure scheduling and data flow impact job performance and efficiency.	CO2, CO3
LSO 9.1.	Develop code for different types of MapReduce jobs (e.g., word count, data aggregation) using various data formats (e.g., text, Avro).	9.	Implement different types of MapReduce jobs (e.g., word count, data aggregation) using various data formats (e.g., text, Avro) by using MapReduce features such as combiners and partitioners.	CO2, CO3
LSO 10.1.	Develop code for Pig Latin scripts for data processing tasks, and compare Pig's execution modes and capabilities with traditional databases.	10.	Write and execute Pig Latin scripts for data processing tasks, and compare Pig's execution modes and capabilities with traditional databases.	CO4
LSO 11.1.	Create user-defined functions (UDFs) and compare Hive's querying capabilities with traditional databases.	11.	Implement user-defined functions (UDFs) and compare Hive's querying capabilities with traditional databases.	CO4
LSO 12.1.	Perform HBase to create tables, perform data operations, and compare HBase with traditional RDBMS in terms of architecture and use cases.	12.	Set up and use HBase to create tables, perform data operations, and compare HBase with traditional RDBMS in terms of architecture and use cases.	CO4
LSO 13.1.	Apply different techniques machine learning algorithms in R for supervised learning (e.g., classification and regression), unsupervised learning (e.g., clustering), and collaborative filtering. Analyze and interpret the results.	13.	Implement machine learning algorithms in R for supervised learning (e.g., classification and regression), unsupervised learning (e.g., clustering), and collaborative filtering. Analyze and interpret the results.	CO5
LSO 14.1.	Write code in R to process and analyze large datasets, demonstrating its integration with R for big data analytics tasks	14.	Use BigR to process and analyze large datasets, demonstrating its integration with R for big data analytics tasks	CO5

K)   Suggested Research Based Problems

i.   **Title:** Improving the Efficiency of Neural Networks for Large-Scale Datasets

Description: Investigate methods to optimize deep neural networks for handling large-scale datasets, focusing on reducing computational costs without sacrificing accuracy. Explore novel

architectures or modifications in the learning process, such as efficient backpropagation methods or pruning techniques to reduce the model size.

ii.   **Title:** Cross-lingual Sentiment Analysis for Low-Resource Languages

Description: Develop a model for sentiment analysis that works effectively across multiple languages, including low-resource languages with limited training data. Explore transfer learning techniques and pre-trained models to enhance performance for sentiment detection on social media platforms in under-represented languages.

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:

   - Apache Hadoop: The Foundation of Big Data Analytics
   - Spark: In-Memory Processing for Real-Time Big Data
   - Big Data Visualization with Tableau and Power BI
   - NoSQL Databases: Scaling Big Data Storage and Management
   - Data Lakes and Their Role in Modern Data Architectures
   - Big Data Integration and ETL Tools: From Data Ingestion to Analysis
   - Data Security and Privacy in Big Data: Tools and Best Practices
   - "Real-Time Data Processing with Apache Flink and Kafka

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 Complex Networks and Graph Theoretic Metrics	11
CO2	Unit 2.0 HDFS (Hadoop Distributed File System)	14
CO1, CO2, CO3	Unit 3.0 Map Reduce	15
CO3, CO4	Unit 4.0 Hadoop Eco System	15
CO2, CO3, CO5	Unit 5.0 Data Analytics with R	15
Total		**70**

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.	java	Java	All

P) **Suggested Learning Resources:**

a) **Books**

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Hadoop: The Definitive Guide	Tom White	Third Edit on, O'reily Media, 2012. ISBN-10: 9352602587 ISBN-13: 978-9352602582
2.	Big Data Analytics	Seema Acharya, SubhasiniChellappan	Wiley 2015, ISBN-10: 0132678209 ISBN-13: 978-0132678209
3.	Big Data Tools and Techniques	Dr. Poornima G. Naik Dr. Girish R. Naik	LAP Lambert Academic Publishing (2024-02-19 ISBN: 978-620-7-46604-7
4.	BIG DATA ANALYTICS: TOOLS AND TECHNOLOGY FOR EFFECTIVE PLANNING	Arun K. Somani and Ganesh Chandra Deka	CRC Big Data Series) ISBN: 978-1138032392

b) **Online Educational Resources (OER):**

1) https://www.youtube.com/watch?v=yTq2qc_eaTk
2) https://www.coursera.org/courses?query=big%20data
3) https://onlinecourses.nptel.ac.in/noc20_cs92/preview
4) https://onlinecourses.nptel.ac.in/noc21_cs45/preview
5) https://onlinecourses.nptel.ac.in/noc20_mg24/preview

Q) **Course Curriculum Developer**

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A)	**Course Title:** Advanced Data Modelling
B)	**Course Code:** CSEB09
C)	**Pre- requisite (s):** Database Management System

D)   Rationale: Data model is the process of developing a conceptual representation of entities with their relationships according to the rules. Moreover, it is used to design a blueprint about the data organization, store and manage them within the database. This will be useful for capturing the important features that are necessary to manage the data and develop the emerging applications with respect to their expectations. The advanced data modelling consists of different data modelling techniques that are all the next version of the basics. The various advanced data modelling techniques include Multidimensional Data Modelling, Temporal Data Modelling, Semi-structured Data Modelling, Data Vault Modelling, Graph Data Modelling, Big Data Modelling and Streaming Data Modelling. The incorporation of these advanced techniques are able to improve the performance, manage the hierarchical relationships, manage big data, capture the time series data and also do the data modelling in cloud.

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
CSEB09.CO1	Use an automated database design tool to design complex database systems.
CSEB09.CO2	Optimize recovery of database transactions in relevant application.
CSEB09.CO3	Apply NOSQL databases to analyze the big data for useful business applications.
CSEB09.CO4	Implement different data models to suit various data representation and storage needs.

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/docum ent.	**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** Use descriptive statistics for decisions making by organizing, analyzing, and visualizing large complex datasets.	**PO-5** Analyze datasets with supervised learning methods for functional approximation, classification, and forecasting and unsupervised learning methods for dimensionality reduction and clustering.	**PO-6** Manage the security and quality of data to ensure its access control and accuracy.
CSEB09.CO1	3	3	3	2	2	-
CSEB09.CO2	3	3	2	3	2	-
CSEB09.CO3	3	3	3	3	3	-
CSEB09.CO4	3	3	3	2	2	-

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

G)   Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Component (TC)		Lab Instruction (LI)	Term Work (TW) + Self Learning (SL)	Total Hours (TC+LI+TW+ SL) (For 15 Weeks)	Total Credits (C)	Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
			Input (I)	Tutorial (T)					Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Term Work Assessment (PTWA)	End Term Work Assessment (ETWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
CSEB09	PEC	Advanced Data Modelling	30	15	30	45	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, 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.　Use the basic retrieval queries to manage the data. TSO 1b.　Perform the unary relational operations on a database. TSO 1c.　Perform the unary relational operations on a database. TSO 1d.　Differentiate the tuple and domain relational calculus. TSO 1e.　Use the entity types, entity sets, attributes and keys.	**Unit-1.0 Introduction** 1.1　SQL data definition and Data types – Specifying Constraints 1.2　Basic Retrieval Queries – INSERT, DELETE, and UPDATE Statements – Additional Features. 1.3　Unary Relational Operations: SELECT and PROJECT 1.4　Binary Relational Operations: JOIN and DIVISION – Tuple Relational Calculus – Domain Relational Calculus 1.5　Entity Types, Entity Sets, Attributes and Keys.	**CO1**
TSO 2a.　Differentiate the subclasses, super classes and Inheritance. TSO 2b.　Use specialization and generalization on database. TSO 2c.　Use data abstraction and ontology to manage the database. TSO 2d.　Design relational database using ER to relational mapping for any database. TSO 2e.　Perform the mapping process over the EER model to build relations for any data of emerging applications.	**Unit-2.0 Enhanced Entity Relationship Model** 2.1　Subclasses, Super classes, and Inheritance 2.2　Specialization and Generalization 2.3　Data Abstraction, Knowledge Representation, and Ontology Concepts 2.4　Relational Database Design Using ER-to-Relational Mapping 2.5　Mapping EER model constructs to Relations.	**CO2**
TSO 3a.　Perform the normalization over the given database using Third Normal form with dependency preservation. TSO 3b.　Perform the normalization over the given database using higher Normal forms with multi-valued dependencies. TSO 3c.　Perform the normalization over the given database using Fourth Normal form and also find the Join dependencies. TSO 3d.　Perform the normalization over the given database using fifth Normal form. TSO 3e.　Perform the normalization over the given database using Boyee /codd Normal form. TSO 3f.　Perform the normalization over the given database using domain key Normal form. TSO 3g.　Differentiate the various normal forms.	**Unit-3.0 Data Normalization** 3.1　The Normalization – Introduction, Non loss decomposition and functional dependencies, 3.2　First, Second, and third normal forms and dependency preservation 3.3　Higher Normal Forms - Introduction, Multi-valued dependencies and Fourth normal form, Join dependencies 3.4　Fifth normal form 3.5　Boyee/Codd normal form 3.6　Domain key Normal Form	**CO3, CO4, & CO5**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 4a. Differentiate the hierarchical and relational data model. *TSO 4b.* Design hierarchical data model for the given problem. *TSO 4c.* Differentiate the various data models available in the NoSQL database. *TSO 4d.* Construct the multidimensional data model for the given problem. *TSO 4e.* Measure the performance of the applications developed by incorporating the various data models.	**Unit-4.0 Data Model-1** 4.1 Hierarchical data model, Relational data model 4.2 NoSQL Data model: Aggregate Models, Document Data Model, KeyValue Data Model, Columnar Data Model, Graph-Based Data Model 4.3 Multidimensional Data Model	**CO4 & CO5**
TSO 5a. Develop an application for handling big data with the incorporation of suitable data model. *TSO 5b.* Develop a real-time application for handling the streaming live data with the incorporation of temporal data model. *TSO 5c.* Develop an application with semi-structured data model *TSO 5d.* Develop an application with probabilistic data model *TSO 5e.* Measure the performance of the various software applications developed with different data models using suitable data modeling tool.	**Unit -5.0 Data Model -2 & Tools** 5.1 Data Modelling for Big data 5.2 Temporal data model 5.3 Streaming data model 5.4 Semi-structured data model 5.5 Probabilistic Data Model 5.6 Data Modelling Tools and Software Applications.	**CO4 & CO5**

J) Suggested Laboratory Experiences:

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant COs Number (s)
LSO 1.1. Construct database queries using Structured Query Language (SQL) *LSO 1.2.* Retrieve and process the specific data. *LSO 1.3.* Manage the retrieved data	1.	Construct an ER/EER model by performing all the basic operations such as INSERT, DELETE, UPDATE, SELECT, JOIN and DIVISION for any scenario.	CO1
LSO 2.1. Create a table for any scenario *LSO 2.2.* Perform the operations including alteration, insertion, aggregation, join, views and sub-queries.	2.	Create a table for any scenario with constraints, alter schema, insert values, aggregate functions, simple and complex queries with joins, Views and Sub-queries.	CO1
LSO 3.1. Perform the fragmentation processes on table. *LSO 3.2.* Design the queries for extracting the data from table of any scenario and implement the *same.*	3.	Consider a schema that contains the following table with the key underlined: Employee (<u>Eno</u>, Ename, Desg, Dno). Assume that we horizontally fragment the table as follows:	CO1 & CO2

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Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant COs Number (s)
LSO 3.3. Add the relations to the concern database as per the requirements.		Employee1(<u>Eno</u>; Ename; Desg; Dno), where 1<= Dno <=10 Employee2(Eno; Ename; Desg; Dno), where 11 <= Dno <=20 Employee3(Eno; Ename; Desg; Dno), where 21 <= Dno <=30 In addition, assume that we have 4 sites such as Site1, Site2, Site3 and Site4 that are having the following fragments: ▪ Site1 has Employee1 ▪ Site2 has Employee2 ▪ Site3 has Employee2 and Employee3 ▪ Site4 has Employee1 Implement at least 5 suitable queries on Employee fragments. Add relations to the database as per your Requirements.	
LSO 4.1. Differentiate the different types of Join operations. *LSO 4.2.* Extract the necessary data by using Equi-Join, Non-Equi-Join and Outer Join queries from a database.	4.	Write SQL queries for extracting data from more than one table (Equi-Join, Non-Equi-Join , Outer Join).	CO1 & CO2
LSO 5.1 Write sub queries and extract the necessary values from a database of a specific application. *LSO 5.2* Write nested queries and retrieve the required data from a database of a specific application.	5.	Write sub queries and nested queries as SQL queries for extracting the required data from a database that was designed for a specific scenario.	CO1 & CO2
LSO 6.1. Differentiate the various higher normal forms. *LSO 6.2.* Apply the higher normal forms on a specific database of any application.	6.	Perform normalization over the database of any application to Higher Normal Forms.	CO3
LSO 7.1. Download the suitable dataset *LSO 7.2.* Import any dataset into MongoDB. *LSO 7.3.* Manage the data of the imported dataset in MongoDB.	7.	Download any temporal dataset and import into MongoDB and manage the data effectively.	CO4 & CO5
LSO 8.1. Create a database with required data by considering the necessary detail.	8.	Create a road cars database with various types of road cars details. In each road car records must have the details of	CO4 & CO5

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant COs Number (s)
LSO 8.2. Test the models towards the consistency and replication schema.		manufacturer and type. Moreover, fix the maximum torque value and the maximum performance of each road car. Finally, test the Consistency models and Cassandras replication schema.	
LSO 9.1. Manage the master data using Neo4j. *LSO 9.2.* Identify the insights in the existing data.	9.	Demonstrate the master data management using Neo4j. Identify the new insights of the master data.	CO4 & CO5
LSO 10.1. Do case study for any kind of applications in real time. *LSO 10.2.* Manage the data of various real-time applications using Cassendra.	10.	Restaurant case study using Cassandra, where we have many customers ordering food items from hotel, we have suppliers who deliver them their ordered food items.	CO4 & CO5

K)   Suggested Research Based Problems

i.   Analyze the outcomes of the injection-related risks in the Neo4j graph database model and its broader ecosystem. This analysis must consider the following with proof through necessary experiments.

- An investigation of the distributed execution of parameterized queries, from language-specific client connectors to communication (Bolt protocol) and execution in Neo4j (in query plans)
- Identifying residual injection problems in cases where parameterized, static queries will not suffice.

The analysis must be a code-centric data flow investigation of the Neo4j code base and is to be complemented with a test suite of injection test cases.

ii.   Generally, this kind of algorithm stores the metadata in the relational system with the consideration of ER Model in which the entity type is represented by a relation in the Relational Model like 1:1 and 1:M relationship with foreign key in the relational model along with a join table that contains the Primary Keys from the original tables. Here, each representing a foreign key and two 1:M relationships between the original tables and the join table. This kind of mapping algorithm is very useful because in practice there are already implemented relational databases with large volume of records. Even though, the response time is high and humans also spared some time to extract the required data. For example, a hospital database that manages patient sheets with different structure at different sections. So that, a new automatic mapping algorithm is necessary to perform the mapping process between the relational databases and MongoDB NoSQL databases. Develop an efficient automatic mapping algorithm for fulfilling the current requirements by performing the mapping process between MongoDB NoSQL database and relational database of a shopping mall database with 8-15 tables. Finally, the efficiency and effectiveness of the algorithm are to be proved by conducting various experiments.

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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:**

- NoSQL and other Non-relational Models
- Identification of New Insights in Master data
- Relational and Graph based data Model
- Role of MongoDB in Data Modelling
- Neo4j in advanced data modelling

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	11
CO2	Unit 2.0 Enhanced Entity Relationship Model	14
CO3, CO4, & CO5	Unit 3.0 Data Normalization	15
CO4 & CO5	Unit 4.0 Data Model-1	15
CO4 & CO5	Unit 5.0 Data Model-2 & Tools	15
Total		70

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.

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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.	RDBMS Software	MySQL/Oracle/SQL Server/MongoDB/ Neo4j/ Cassandra	All

P)   Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Knowledge Discovery from Data Streams	Joao Gama	CRC Press, 2010.
2.	The Power of Events: An Introduction to Complex Event Processing in Distributed Enterprise Systems	David Luckham	Addison Wesley, 2002.
3.	Data Streams: Models and Algorithms	Charu C. Aggarwal	Kluwer Academic Publishers, 2007

b) Online Educational Resources (OER):

1) https://elearn.nptel.ac.in/shop/partnering-courses/level-up-your-data-modeling-skills-advanced-techniques-for-data-architects/?v=c86ee0d9d7ed
2) https://www.sciencedirect.com/science/article/abs/pii/S016740482300500X
3) An algorithm for mapping the relational databases to mongodb - a case study (researchgate.net)
4) https://www.javatpoint.com/nosql-databases
5) https://www.w3schools.com/mongodb/
6) https://www.javatpoint.com/neo4j-tutorial

Q)   Course Curriculum Developer

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A)	**Course Title:** Streaming Data Analytics
B)	**Course Code:** CSEB10
C)	**Pre- requisite (s):**

D)   Rationale: Streaming data is the continuous flow of data generated by various sources. By using stream processing technology, data streams can be processed, stored, analyzed, and acted upon as it's generated in real-time. Similarly, data streams are generated by all types of sources, in various formats and volumes. Moreover, the data streams are generated from various applications, networking devices, and server log files, to website activity, banking transactions, and location, and these are all aggregated to seamlessly gather real-time data and analytics from a single source of truth. Generally, the real-time streaming analytics is useful for a range of industries by spotting opportunities and risks. Moreover, the advantages of Streaming Analytics including Data visualization, Business insights, Increased competitiveness, cutting preventable losses and Analyzing routine business operations. These streaming data analytics are helpful for creating new business models with innovative ideas and generating more revenue stream.

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
CSEB10.CO1	Implement different algorithms for analysing the data streams to solve real-world problems.
CSEB10.CO2	Develop a new data streaming model for the various companies.
CSEB10.CO3	Improve the performance of the different companies through data streaming models.
CSEB10.CO4	Evaluate the model by using the necessary metrics.

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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/docume nt.	**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** Use descriptive statistics for decisions making by organizing, analyzing, and visualizing large complex datasets.	**PO-5** Analyze datasets with supervised learning methods for functional approximation, classification, and forecasting and unsupervised learning methods for dimensionality reduction and clustering.	**PO-6** Manage the security and quality of data to ensure its access control and accuracy.
CSEB10.CO1	3	3	3	3	3	-
CSEB10.CO2	3	3	3	3	3	-
CSEB10.CO3	3	3	3	3	2	-
CSEB10.CO4	2	2	2	2	3	-

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

G)   Teaching & Learning and Assessment Scheme:

Course Code	Course Category	Course Titles	Teaching & Learning Scheme (Hours)						Assessment Scheme (Marks)						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)	
CSEB10	PEC	Streaming Data Analytics	45	15	30	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, and renewable energy are integrated appropriately.

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I)   Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Differentiate the characteristics of data streams. TSO 1b. Distinguish the challenges in mining data streams. TSO 1c. Write the requirements for the various real time processing TSO 1d. Analyze the principles of real time processing TSO 1e. Explain the concept drift incremental learning	**Unit-1.0 Introduction** 1.1 Characteristics of the data streams 1.2 Challenges in mining data streams 1.3 Requirements and principles for real time processing 1.4 Concept drift Incremental learning	**CO1**
TSO 2a. Perform various operations on streaming data using basic streaming methods TSO 2b. Use various Poisson processes on streaming data TSO 2c. Perform the various statistical analyses for the data streaming processes including data streaming, sliding and synopsis. TSO 2d. Perform the change detection process on streaming data using tracking drifting concepts through monitoring and learning process.	**Unit-2.0 Data Streams** 2.1 Basic Streaming Methods, Counting the Number of Occurrence of the Elements in a Stream, Counting the Number of Distinct Values in a Stream, Bounds of Random Variables, 2.2 Poisson Processes 2.3 Maintaining Simple Statistics from Data Streams, Sliding Windows, Data Synopsis 2.4 Change Detection: Tracking Drifting Concepts, Monitoring the Learning Process	**CO2**
TSO 3a. Analyze the VFDT TSO 3b. Apply the VFDT on various kinds of streaming data TSO 3c. Develop the enhanced version of VFDT for better performance on various streaming data TSO 3d. Evaluate the VFDT and the enhanced version by using the necessary evaluation metrics.	**Unit-3.0 Decision Trees** 3.1 The Very Fast Decision Tree Algorithm (VFDT) 3.2 The Base Algorithm, Analysis of the VFDT Algorithm, 3.3 Extensions to the Basic Algorithm: Processing Continuous Attributes, Functional Tree Leaves, Concept Drift 3.4 Measure the performance of decision trees using standard metrics	**CO3, CO4, & CO5**
TSO 4a. Differentiate the various clustering algorithms TSO 4b. Identify the suitable clustering algorithm to group the streaming data for analysis. TSO 4c. Apply suitable clustering algorithm for the specific type of streaming data. TSO 4d. Evaluate the clustering algorithms by considering the necessary evaluation metrics.	**Unit-4.0 Clustering from Data Streams** 4.1 Clustering Examples: Basic Concepts, Partitioning Clustering – 4.2 The Leader Algorithm, 4.3 Single Pass k-Means, 4.4 Micro Clustering, 4.5 Clustering Variables: A Hierarchical Approach 4.6 Evaluation methods and metrics	**CO4 & CO5**

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Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 4e. Do the comparative analysis between the clustering algorithms with respect to the necessary evaluation metrics.		
TSO 5a. Perform frequent itemset mining over the streaming data *TSO 5b.* Identify the recent frequent itemsets on a specific streaming data *TSO 5c.* Find the sequence pattern mining over the streaming data *TSO 5d.* Apply the reservoir sampling approach to perform the sequential pattern mining on streaming data. *TSO 5e.* Evaluate the frequent pattern mining technique by considering the standard evaluation metrics.	**Unit 5.0 Frequent Pattern Mining** 5.1 Mining Frequent Itemsets from Data Streams- Landmark Windows, Mining Recent Frequent Itemsets, Frequent Itemsets at Multiple Time Granularities 5.2 Sequence Pattern Mining 5.3 Reservoir Sampling for Sequential Pattern Mining over data streams 5.4 Evaluation and error estimation process	**CO4 & CO5**
TSO 6a. Identify the various features of CEP based on the requirements for the specific applications. TSO 6b. Differentiate the roles of various layers of CEP on specific problem solving. TSO 6c. Identify the suitable event patterns by using the generated rules with respect to the event hierarchies.	**Unit-6.0 Complex Event Processing** 6.1 Introduction to Complex Event Processing, Features of CEP, Need for CEP, CEP Architectural Layers, Scaling CEP, 6.2 Events, Timing and Causality, Event Patterns, Rules and Constraint, STRAW-EPL, Complex Events and Event Hierarchies	**CO3 & CO4**

J)   Suggested Laboratory Experiences:

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant COs Number (s)
LSO 1.1. Design a stream processing engine with two classes. *LSO 1.2.* Implement the stream processing engine. *LSO 1.3.* Measure the performance of the stream processing engine with respect to the evaluation metrics.	1.	Exploring one stream processing engine like storm or STREAM etc. (2 classes)	CO1
LSO 2.1. Implement VFDT and CVFDT algorithms *LSO 2.2.* Evaluate the decision tree algorithms using standard metrics.	2.	Implementation of algorithms for example : VFDT, CVFDT (2 classes)	CO1
LSO 3.1. Develop the clustering algorithm for grouping the streaming data of a specific application.	3.	Implementation of Clustering	CO1, CO2

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant COs Number (s)
LSO 3.2. Measure the clustering algorithm by considering the necessary evaluation parameters.			
LSO 4.1 Develop the clustering algorithm for grouping the streaming data of a specific application. LSO 4.2 Measure the clustering algorithm by considering the necessary evaluation parameters.	4.	Implementation of Frequent pattern mining	CO1, CO2
LSO 5.1. Design a CEP engine with two classes for the specific streaming data. *LSO 5.2.* Measure the performance of the CEP Engine.	5.	Exploring one CEP engine like ESPER or DROOLS (2 classes)	CO1, CO2
LSO 6.1. Write and execute the number of queries to perform logical operations over a single stream of data.	6.	Exercise with continuous queries Logical operations on single stream	CO1, CO2
LSO 7.1. Write and execute the number of queries to perform logical operations over a multiple stream of data.	7.	Exercise with continuous queries Logical operations on multiple streams	CO1, CO2
LSO 8.1. Write and execute the number of queries to perform temporal operations over a single stream of data.	8.	Exercise with continuous queries temporal operators on single stream.	CO1, CO3
LSO 9.1. Write and execute the number of queries to perform temporal operations over a single stream of data.	9.	Exercise with continuous queries temporal operators on multiple streams	CO1, CO4
LSO 10.1. Develop and execute the number of queries with logical, relational and temporal operators over a multiple stream of data.	10.	Exercise with complex continuous queries with logical, relational & temporal operators on multiple streams.	CO5, CO1

K)   Suggested Research Based Problems

    i.   Applications and infrastructures designed to support Fog Computing in Internet of Things environments generate large volumes of data. Generally, these are all characterized as open-ended streams, thus making unfeasible the adoption of traditional modelling approaches. Here, the various challenges are facing by the researchers to incorporate an offline model, high computational complexity and server storage and processing capacity. Main aim of this research is to overcome the challenges available in this direction. For this purpose, need to develop a new deep neural classifier with fog computing. Initially, the proposed model considers the Wavelet Transform to under-sample data streams without losing details about their main behaviour. Next, it uses any one of the existing Concept Drift algorithms to transmit the data in the environment when a new behaviour is detected. The model needs to perform the following tasks.

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- Identify the necessary two steps to reduce the processed and exchanged data using deep neural classifier.
- Develop an incremental approach to model data streams efficiently in Fog Computing
- Introduce a new technique to Reduce data transmission between computational resources, thus making it possible to save energy in IoT scenarios

Formulate as a new model and prove the efficiency and effectiveness of the same towards handling the streaming data.

ii. Recently, insufficient sales prediction easily leads to the untimely dispatch of supply and causes inventory problems, resulting in a loss of profits for merchants. Previous sales prediction research was mainly based on traditional e-commerce platforms that cannot be directly applied to live streaming e-commerce, which adds many important elements. The main objective of this work is to design a multimodal analytics framework for product sales prediction in live streaming e-commerce. The newly developed prediction system is to be capable of doing the following:

- Explore the influence of anchor reputation on product sales and innovatively consider both historical and real-time reputation signals.
- Extract the better valuable information for real-time signals using a new technique to extract features from product text and images
- Use a real-world dataset collected from Douyin live streaming for conducting experiments

The experimental results demonstrate the effectiveness of the new framework towards predicting the sales.

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:

- Streaming data Analytics in e-Healthcare
- Streaming data Analytics in Education
- Streaming data Analytics Tools
- Streaming data Analytics in Business
- Streaming data Analytics in Agriculture

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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	08
CO2	Unit 2.0 Data Stream	08
CO3, CO4, & CO5	Unit 3.0 Decision Trees	12
CO4 & CO5	Unit 4.0 Clustering from Data Streams	14
CO4 & CO5	Unit 5.0 Frequent Pattern Mining	14
CO3 & CO4	Unit 6.0 Complex Events Processing	14
Total		**70**

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.	Anaconda with Jupiter Notebook	Anaconda 3.1 Version	1 to 4
3.	Java / .NET	JVM / Visual Studio	5 to 10
4.	ESPER	ESPER for Java / ESPER for .NET	5 to 10

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P)   Suggested Learning Resources:

a) Books

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Knowledge Discovery from Data Streams	Joao Gama	CRC Press, 2010.
2.	The Power of Events: An Introduction to Complex Event Processing in Distributed Enterprise Systems	David Luckham	Addison Wesley, 2002.
3.	Data Streams: Models and Algorithms	Charu C. Aggarwal	Kluwer Academic Publishers, 2007

b) Online Educational Resources (OER):

1) https://archive.nptel.ac.in/courses/106/104/106104189/
2) http://www.liaad.up.pt/area/jgama/DataStreamsCRC.pdf
3) https://www.udemy.com/course/master-big-data-realtime-streaming/
4) https://www.tutorialspoint.com
5) Data Source
   - https://www.kaggle.com
   - UNSW dataset
   - UCI Machine Learning Repository

Q)   Course Curriculum Developer

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A)	**Course Title:** Next Generation Databases
B)	**Course Code:** CSEB11
C)	**Pre- requisite (s):** Database Management Systems

D)   Rationale: Evolution of database is necessary to manage the huge volume of data available in this current internet world. Database management systems are to be enriched with respect to the development of computer usage. For this purpose, next generation databases are becoming popular and these are useful for enriching the performance of the database professionals towards the current context in Information Technology and business. So that the Next-generation database technologies are at the forefront of revolutionizing data management, offering solutions that transcend traditional constraints. Moreover, the available next-generation database technologies transcend the limitations of their predecessors by excelling in managing complex relationships, enabling real-time analytics, and embracing emerging paradigms. In addition, the Next-generation database technologies offering the flexibility, Schema-less Design, Real-Time Analytics, Scalability, Advanced Query Optimization and Integration with Emerging Technologies. This course will be helpful for the database administrator, data engineers and data analyst to enrich their decision-making process by handling the data efficiently.

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
CSEB11.CO1	Analyze the databases of different business applications.
CSEB11.CO2	Apply columnar and distributed database patterns to handle huge data of an application.
CSEB11.CO3	Implement the big data revolution method to extract the hidden data from application.
CSEB11.CO4	Improve the performance of the various data models for a wide range of databases.

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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/docume nt.	**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** Use descriptive statistics for decisions making by organizing, analyzing, and visualizing large complex datasets.	**PO-5** Analyze datasets with supervised learning methods for functional approximation, classification, and forecasting and unsupervised learning methods for dimensionality reduction and clustering.	**PO-6** Manage the security and quality of data to ensure its access control and accuracy.
CSEB11.CO1	3	3	3	-	3	-
CSEB11.CO2	3	3	3	2	3	-
CSEB11.CO3	3	3	2	2	3	-
CSEB11.CO4	2	2	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)	
CSEB11	PEC	Next Generation Databases	45	15	30	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, and renewable energy are integrated appropriately.

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I)   Theory Session Outcomes (TSOs) and Units:

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 1a. Explain the various types of databases. TSO 1b. Design a relational database for an application. TSO 1c. Perform the data transaction for any application TSO 1d. Retrieve the required data from repository	**Unit-1.0 Introduction** 1.1 Database Revolutions 1.2 System Architecture 1.3 Relational Database 1.4 Database Design 1.5 Data Storage Transaction Management 1.6 Data Warehouse and Data Mining 1.7 Information Retrieval	**CO1**
TSO 2a. Differentiate the various data revolution TSO 2b. Apply CAP theorem to differentiate two or more databases TSO 2c. Use the document databases for storing the data effectively and efficiently. TSO 2d. Find the complex relationship patterns between the databases TSO 2e. Store the large volume of data in online through XML database	**Unit-2.0 Document Databases** 2.1 Big Data Revolution 2.2 CAP Theorem 2.3 Birth of NoSQL 2.4 Document Database 2.5 XML Databases 2.6 JSON 2.7 Document Databases 2.8 Graph Databases.	**CO2**
TSO 3a. Analyze the huge volume of data column wise instead of row. TSO 3b. Differentiate the data warehousing schemas for ease of access the data. TSO 3c. Optimize the business and big data analytics solutions cost effectively. TSO 3d. Present the big data effectively for ease of understanding and accessing. TSO 3e. Provide quick data access facility to the users / customers for accessing their regularly used items.	**Unit-3.0 Column Databases** 3.1 Column Databases 3.2 Data Warehousing Schemas 3.3 Columnar Alternative 3.4 Sybase IQ 3.5 CStore and Vertica 3.6 Column Database Architectures 3.7 SSD and In-Memory Databases 3.8 In-Memory Databases 3.9 Berkeley Analytics Data Stack and Spark	**CO3 & CO4**
TSO 4a. Parallelize the queries easily across the multiple nodes based on the data the users/customers wish to access. TSO 4b. Use MongoDB for ease of maintain and access. TSO 4c. Manage the subset of the dataset. TSO 4d. Store and manage the non-relational data by using HBase. TSO 4e. Maintain the low-latency, high-throughput, and seamless scalability of data.	**Unit-4.0 Distributed Databases** 4.1 Distributed Database Patterns 4.2 Distributed Relational Databases 4.3 Non-relational Distributed Databases 4.4 MongoDB 4.5 Sharding and Replication 4.6 HBase 4.7 Cassandra 4.8 Consistency Models 　　　 - Types of Consistency 　　　 - Consistency in MongoDB	**CO3 & CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 4f. Maintain the data synchronization between the different processes.	- HBase Consistency - Cassandra Consistency.	
TSO 5a. Create a system to serve their customers without schemas. TSO 5b. Handle any kind of data effectively. TSO 5c. Replicate the data through mobile remotely. TSO 5d. Perform the comparative evolutionary analysis. TSO 5e. Create new business opportunities through disruptive database technologies.	**Unit -5.0 Data Models & Storage** 5.1 Data Models and Storage 5.2 SQL - NoSQL APIs - Return of SQL - Advance Databases - Postgre SQL 5.3 Riak - CouchDB - NEO4J – Redis 5.4 Future Databases 5.5 Revolution Revisited 5.6 Counter revolutionaries 5.7 Oracle HQ 5.8 Other Convergent Databases 5.9 Disruptive Database Technologies.	**CO3 & CO4**

J)   Suggested Laboratory Experiences:

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant COs Number (s)
LSO 1.1. Construct database queries using My Structured Query Language (MySQL) LSO 1.2. Retrieve and process the specific data. LSO 1.3. Manage the retrieved data	1	Construct an ER/EER model by using MySQL for performing all the basic operations such as INSERT, DELETE, UPDATE, SELECT, JOIN and DIVISION for any scenario.	CO1
LSO 2.1. Construct a parse tree LSO 2.2. Implement the XML inputs into the parse tree	2	Construct the parse tree for the following XML inputs: a) <bubble speaker="phb">Um... No.</bubble> : b) Parse tree for the "minimal" XML document c) <?xml version="1.0"?><foo/	CO1
LSO 3.1. Design a document data model by considering the given inputs. LSO 3.2. Assign the suitable key values for their pair and manage them.	3	Design a document data model using XML for three simple applications that are holding a pair of key-values.	CO2
LSO 4.1. Write a program to handle the JSON data. LSO 4.2. Identify three different real-time applications with the relevant key pair values by considering the escape strings.	4	Use string->json to define 3 of your own examples of some JSON data by considering the escape strings.	CO2
LSO 5.1 Differentiate the CStore and Commercial DBMS.	5	Write queries against the CStore Vs commercial DBMS and evaluate the performance of the queries.	CO2

Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment Titles	Relevant COs Number (s)
LSO 5.2 Apply the queries against CStore and evaluate their performance.			
LSO 6.1. Create a database using column store. LSO 6.2. Create a database using row store. LSO 6.3. Evaluate both the column store and row store methods performance based on the performance of the databases.	6	Demonstrate the efficiency of column store and row store and identify the best method for a real time application.	CO2 & CO3
LSO 7.1. Install and configure the MongoDB to execute the NoSQL commands. LSO 7.2. Manage the database by performing all the operations.	7	To install and Configure MongoDB to execute NoSQL commands by considering an application and manage the database.	CO3
LSO 8.1. Create a road car database by considering the different car names, manufacturer name and type. LSO 8.2. Find the maximum torque value and performance value. LSO 8.3. Evaluate and measure the performance of the model.	8	Create a road cars database with various types of road cars details. In each road car records must have the details of manufacturer and type. Moreover, fix the maximum torque value and the maximum performance of each road car. Finally, test the Consistency models and Cassandras replication schema.	CO3 & CO4
LSO 9.1. Design a database schema LSO 9.2. Implement the queries using HBase and Cassendra column based database LSO 9.3. Evaluate the database schemas.	9	Design database schemas and implement minimum 10 queries using Hbase and Cassendra column based databases	CO3 & CO4
LSO 10.1. Implement the path finding algorithms LSO 10.2. Evaluate the algorithms with respect to the evaluation metrics.	10	Implement the following path finding algorithms by using Neo4j. i) Dijikstra ii) A* Evaluate the algorithms by considering the necessary evaluation metrics.	CO4

K)   Suggested Research Based Problems

   i.   Generally, the graph-based databases are considered the flexibility and performance. Majority of the earlier techniques applied for designing the NoSQL databases and not considered the security and authorization issues. To ensure the security of the database, the objective of this research work is to develop ascetic framework with the incorporation of secured Graph databases. Here, an ontological table needs to be designed and incorporate in to the newly developed framework for analyzing the users' behaviour. The new secured graph database ensures the database security by applying the security rules and referring the ontology. Finally, the secured framework needs to be evaluated by conducting experiments with different number of users' behaviours.

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ii.   Time-varying JSON data are used and interchanged in different frameworks including IoT platforms, online social networks, and web applications. Even though as per the literature, the JSON data management is not standard still due to the manipulation activities carried out in the database. For avoiding this frequent manipulation, the temporal JSON data is used for maintaining the temporal relational data. Moreover, the existing JSON-based NoSQL DBMSs namely MongoDB, Riak, commercial relational DBMSs and PostgreSQL and MySQL to support the JSON documents that are not able to facilitate the temporal JSON data maintenance. This research work is to create a new temporal Update and JSchema. At the end, the experiments have been done and proved as a better than other available frameworks.

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.

- Write down a command that will add age to 'alex' using HBase.
- How can we update the age in row2 using HBase.
- How can we use 'scan' to show all rows with a value under the column 'data:age' using HBase.
- Imagine the entry in row3 changes from Vancouver to New York using HBase.
- How can we add a new city in 'data:city' for row3 without losing the previous city using HBase.
- How can we use 'scan' to show all versions in all cells using HBase.
- Imagine a user made a mistake when entering the new city and misspelled the word 'New York' for row3 using HBase.
- How can we change the last version of 'data:city' without creating a new version using HBase.
- Try adding gender information using the following command: $ put 'test', 'row3', 'personal:gender', 'male' Explain what went wrong and how the problem can be fixed using HBase.

b.   Seminar Topics:

- HBase in future database
- Riak Vs commercial relational DBMSs Vs PostgreSQL
- Relational Databases Vs Graph based Databases
- Role of MongoDB in next generation database
- Neo4j in next generation database

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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	11
CO2	Unit 2.0 Document Databases	14
CO3 & CO4	Unit 3.0 Column Databases	15
CO3 & CO4	Unit 4.0 Distributed Databases	15
CO3 & CO4	Unit 5.0 Data Models & Storage	15
Total		**70**

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.	RDBMS Software	MySQL/Oracle/SQL Server/MongoDB/ Neo4j/ Cassandra	All

P) **Suggested Learning Resources:**

a) **Books**

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Database System Concepts	Abraham Silberschatz, Henry F. Korth, S. Sudarshan	Sixth Edition, McGrawHill
2.	Next Generation Databases	Guy Harrison	Apress, 2015
3.	Seven Databases in Seven Weeks	Eric Redmond, Jim R Wilson	LLC. 2012

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S. No.	Titles	Author(s)	Publisher and Edition with ISBN
4.	NoSQL for Mere Mortals	Dan Sullivan	Addison-Wesley, 2015.
5.	NoSQL for Dummies	Adam Fowler	John Wiley & Sons, 2015.

b) Online Educational Resources (OER):

1) https://elearn.nptel.ac.in/shop/partnering-courses/level-up-your-data-modeling-skills-advanced-techniques-for-data-architects/?v=c86ee0d9d7ed
2) https://www.sciencedirect.com/science/article/abs/pii/S016740482300500X
3) An algorithm for mapping the relational databases to mongodb - a case study (researchgate.net)
4) https://www.javatpoint.com/nosql-databases
5) https://www.w3schools.com/mongodb/
6) https://www.javatpoint.com/neo4j-tutorial

Q)   Course Curriculum Developer

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

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

2. **Teaching & Learning and Assessment Scheme:**

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

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- 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

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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:**

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

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S. No.	Criterion	Very Good (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
		different from existing work.	Offers partial innovation.	significant innovation.	
2.4	**Resourcefulness**	Demonstrates exceptional initiativeness and creativity in utilizing/arranging resources effectively.	Shows good use of resources and tools. Demonstrate moderate initiativeness and creativity in utilizing/ arranging resources.	Makes basic use of resources with limited initiative. Relies heavily on guidance.	Shows poor ability of utilizing/arranging resources.
2.5	**Sustainability**	Project demonstrates strong sustainability considering all aspects like- environmental, economic, and social impacts.	Project demonstrates moderate sustainability practices considering some aspects like- environmental, economic, and social impacts.	Project demonstrates limited sustainability practices considering some aspects like- environmental, economic, and social impacts.	Project lacks sustainability considerations.
2.6	**Maintaining Daily Diary or Log Book**	Diary/log book is consistently and meticulously maintained. Entries are detailed, dated, and clearly reflect daily progress.	Diary/log book is periodically maintained with relevant entries. Most entries are dated and show a good record of activities and progress.	Diary/log book is maintained irregularly. Entries are brief or lack detail.	Diary/log book is poorly maintained or mostly incomplete. Important entries are missing or unclear.
3.	**Quality of Product/Process** **Outcome:** Ensure the Quality of Product/Process				
3.1	**Originality of Product**	The final product is original and creative. It presents unique features, functions, or designs not found in existing solutions.	The final product is somewhat original with some creative elements or improvements over existing ideas.	The product has limited originality. Mostly based on existing ideas or minor modifications.	The product lacks originality. It is a direct reproduction of existing work with no new features or creative input.
3.2	**Cost Effectiveness of Product/Process**	Process and/ product are highly cost-effective. Optimal use of resources. Demonstrates strong value-for-money.	Process and/ product are reasonably cost-effective. Resources are mostly used wisely, with acceptable cost.	Process and/ product show limited cost-effectiveness.	Process and/ product are not cost-effective. Inefficient use of resources.
3.3	**Proposed Outcomes Achieved**	All proposed outcomes are fully achieved.	Most of the proposed outcomes are achieved with satisfactory quality.	Some proposed outcomes are achieved with minor gaps.	A few or none of the proposed outcomes are achieved.
4.	**Project Report Writing** **Outcome:** Write Quality Project Report				
4.1	**Style and Language**	Language is clear, precise, and academically appropriate	Language is generally clear and appropriate. Style is mostly formal and	Language is understandable, but is informal. Style occasionally	Language is unclear, informal, or inappropriate for a technical report.

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S. No.	Criterion	Very Good (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
		throughout. Style is formal, consistent, and well-suited, hence enhancing the overall quality of the report.	consistent. The quality of the report is acceptable.	deviates from the formal standards. The quality of the report is moderate	Style is inconsistent and affects the quality of the report.
4.2	**Quality of Related Diagrams/Drawings/Graphs in Project Report**	Diagrams/ drawings/ graphs are highly relevant, accurate, well-labelled and neatly presented.	Diagrams/ drawings/ graphs are mostly accurate, clear, and mostly relevant to the content. Properly labelled and adequately formatted.	Diagrams/ drawings/ graphs are present but lack clarity, proper labelling, or relevance.	Diagrams/ drawings/ graphs are missing/ incorrect, or poorly presented.
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	Slides are well-structured. Content is mostly relevant and supports the spoken presentation. Visuals are used appropriately. Minor	Slides have a basic structure but are cluttered. Lack proper visual support. Too much of text. Font size	Slides are poorly designed or difficult to read. Content is disorganized, excessive, or irrelevant. Visuals are missing or

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S. No.	Criterion	Very Good (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)
		presentation effectively. Excellent use of visuals (e.g., graphs, images, icons). Fonts, size, colours, and layout enhance readability.	issues in font size, colour, and layout.	and colour is not appealing.	irrelevant. Font size and colour are poor.
5.4	**Ability to Defend Questions**	Responds to all questions confidently, accurately and with deep understanding and proper justifications.	Responds to most questions correctly and confidently. Demonstrates good understanding with minor gaps in Justifications.	Responds to basic questions with partial accuracy. Shows limited understanding with weak justifications.	Unable to answer questions clearly or correctly. Responses reflect poor understanding.

Format 2

Project Report

1. **Name of the Programme:**
2. **Broad Area/Theme of the Project:**
3. **Title of the Project:**
4. **Rationale:**
5. **Objectives:**
6. **Scope of the Project:**
7. **Literature Survey:**
8. **Methodology used (as applicable):**
     i. Resources used
    ii. Test
   iii. Sampling
    iv. Method
     v. Model
    vi. Any other (please specify)
9. **Observation, Analysis, and Interpretation:**
10. **Reporting of Results and Conclusion:**
11. **Project Future Potential:**
12. **References:**
13. **Bibliography:**
14. **Annexure (as applicable):**

D) Course Curriculum Development Team

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Course Curriculum Detailing- Online Spell -1

S. No.	Course Codes	Course Titles	Page No.
1.	PC01	Research Methodology	129
2.	PC02	Curriculum & Assessment	135
3.	NEP06	Indian Knowledge System (IKS)	142

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A)	**Course Title:** Research Methodology
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

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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.

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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**

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Major Theory Session Outcomes (TSOs)	Units	Relevant CO Number(s)
TSO 5a. Illustrate the Structure of a Good Research Proposal	**Unit -5.0 Research Proposal**	CO5
TSO 5b. Write good research proposal	5.1 Getting Started to Write a Research Proposal	
TSO 5c. List the tips for compilation	5.2 Tips for Compilation	
TSO 5d. Classify the types of scientific report	5.3 Scientific writing: types of scientific report	
TSO 5e. Develop structure and components of the conference	5.4 Structure and components of a conference	
TSO 5f. Write the report with ethics and scientific conduct	5.5 Arts of writing, ethics, and scientific conduct	
TSO 5g. Analyze the presenting work is from another source with or without consent of the original author	5.6 Journal articles and thesis writing	
	5.7 Plagiarism	

J) Suggested Laboratory Experiences: (Not Applicable)

K) Suggested Research Based Problems

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

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

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

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

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

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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)

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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_P8lgjvmqi DEoFGLzG4h
   8)   https://www.youtube.com/watch?v=NNPiJ20JcFI&list=PLyqSpQzTE6M8F_P8lgjvmqiDE oFGLzG4h&index=8

Q)   Course Curriculum Development Team

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A)	**Course Title:** Curriculum & Assessment
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.

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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.

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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

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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.

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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

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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.LOKAN ADHA 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

S. No.	Name	E-mail Address
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A)	**Course Title:** Indian Knowledge System (IKS)
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 (-)

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G) Teaching & Learning and Assessment Scheme:

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

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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?

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- 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.

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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.

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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.

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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

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A)	**Course Title:** MOOC Creation
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.

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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.

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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. 4.2 Overview of SWAYAM MOOC structure.	**CO5**

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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.	4.3 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

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      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

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P)   Suggested Learning Resources:

  a) Books

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

  b) Online Educational Resources (OER):

  1)   https://storage.googleapis.com/swayam2_central/swayam1/wqimgtest_f8b95943-b963-49b9-85ed-416f2e15d1b4.pdf

  2)   https://storage.googleapis.com/swayam2_central/swayam1/UGC_Gazette-Credit_Framework_for_Online_Courses_through_SWAYAM.pdf

  3)   https://storage.googleapis.com/swayam2_central/swayam1/wqimgtest_9da02ba8-bdd8-409c-afdb-645e6dbc544f.pdf

  4)   https://swayam.gov.in

  5)   https://pmevidya.education.gov.in/swayam-portal.html

  6)   https://swayam.inflibnet.ac.in

  7)   https://spoken-tutorial.org

  8)   https://epgp.inflibnet.ac.in

  9)   https://search.creativecommons.org

Q)   Course Curriculum Development Team

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A)	**Course Title:** Learner Centric Instructional Methods
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.

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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.

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I)   Theory Session Outcomes (TSOs) and Units:

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

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

J)   Suggested Laboratory Experiences: (Not Applicable)

K)   Suggested Research Based Problems

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

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

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

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

L)   Suggested Term Work (TW):

a.   Assignment(s):

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

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

b.   Seminar Topics:

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

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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
6.	Teaching Strategies: A Guide to Effective Instruction	Donald C. Orlich, Robert J. Harder, Michael S.	Cengage Learning, 2016, Eleventh Edition,

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

b) Online Educational Resources (OER):

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

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A)	**Course Title:** Intellectual Property Rights (IPR)	
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.

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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/docume nt**.**	**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 advance d 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 commitmen t to improve kno wledge and competence continuousl y.
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.

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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

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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

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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

S. No.	Name	E-mail Address
1.	Prof. C. S. Rajeshwari	csrajeshwari@nitttrbpl.ac.in

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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)

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