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

# Information Booklet

*of*

# Doctoral Programme

# Ph.D.


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## Foreword

It is with great pride and enthusiasm that I present this Ph.D. Curriculum Booklet, a comprehensive guide to the academic and research framework that defines our doctoral programs. The pursuit of a Doctor of Philosophy (Ph.D.) represents the highest level of academic inquiry, fostering innovation, critical analytical thinking, and scholarly contributions that shape the future of knowledge and society.

At NITTTR Bhopal, we are committed to providing a rigorous, multidisciplinary, and research-driven environment that empowers scholars to explore complex problems, contribute meaningful insights, and advance the frontiers of their respective disciplines. This curriculum has been meticulously designed to uphold the highest academic standards while offering flexibility to accommodate emerging areas of research.

The booklet outlines essential components of our Ph.D. program, including **coursework, Curriculum detailing, research methodology, thesis requirements, and evaluation criteria**. It also provides insights into our research ethos, mentorship framework, and the vast resources available to scholars for intellectual growth. We emphasize an ecosystem of academic excellence, ethical research practices, and global engagement, ensuring that our scholars are well-prepared to address contemporary challenges with scientific rigor and societal impact.

I extend my sincere appreciation to the faculty, research supervisors, and academic committees who have contributed to the development of this curriculum. Their unwavering commitment to academic excellence ensures that our Ph.D. program remains at the forefront of knowledge creation.

To all aspiring researchers embarking on this transformative journey, I encourage you to engage deeply with the curriculum, embrace curiosity, and contribute to the advancement of your field with dedication and integrity. Your research has the potential to influence policies, industries, and global perspectives, and we are here to support you every step of the way.

Wishing you success in your academic and research endeavours.

**Dr C C Tripathi**
**Director**
**NITTTR, Bhopal**

## Acknowledgement

The successful completion of this Ph.D. Curriculum Booklet is the result of the collective wisdom, dedication, and commitment of numerous individuals who have contributed their expertise to shape this document into a comprehensive academic guide.

I extend our deepest gratitude to the leadership of Dr C C Tripathi, Director NITTTR Bhopal for their visionary guidance and unwavering support in fostering a robust research ecosystem. Their encouragement has been instrumental in developing a curriculum that upholds academic excellence while embracing innovation and interdisciplinary scholarship.

A special appreciation is due to Dr. Anju Rawlley, Dr. R. K. Kapoor, Dr. Basheerullah Shaikh, Dr. Roli Pradhan and other members of the Academic team whose expertise and invaluable contributions have been the cornerstone of this endeavour. Their dedication to maintaining the highest academic standards has ensured that this curriculum not only meets but exceeds the expectations of a globally competitive research framework. Their valuable insights and constructive feedback, helped us align the curriculum with the evolving frontiers of knowledge and research. Their contributions underscore the spirit of continuous improvement and academic excellence.

I, sincerely acknowledge the editorial and administrative teams, whose meticulous efforts in compiling, structuring, and refining this booklet have made it a well-organized and accessible resource. Their diligence and attention to detail have played a crucial role in its successful completion.

Finally, I extend my heartfelt appreciation to all individuals, institutions, and stakeholders who have, in various capacities, supported this initiative. Your collective efforts have helped create a curriculum that not only nurtures scholarly inquiry but also prepares researchers to make meaningful contributions to society.

It is our hope that this booklet serves as an indispensable guide for all aspiring scholars, equipping them with the knowledge and framework necessary for a transformative and impactful research journey.

**(Dr. Sanjay Agrawal)**
**Dean Academic and Research, NITTTR Bhopal**

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**Prof. (Dr.) C. C. Tripathi**
**NITTTR, Bhopal**

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# Contents

## 1. About the University

The National Institute of Technical Teachers' Training and Research (NITTTR), Bhopal (formerly known as Technical Teachers' Training Institute, Bhopal), was established in 1965 by the Government of India as part of an ongoing scheme to enhance the quality of technical education. Initially, the institute offered short-term and long-term teacher training programs for technical educators, aiming to develop professional competence among polytechnic teachers. The objectives were incorporated in EFC Memo no. 23-24/65/T.1 of June 1966. The institute provided need-based training to improve the overall technical education system in the states of Chhattisgarh, Goa, Gujarat, Madhya Pradesh, Maharashtra, and the Union Territory of Daman, Diu, Dadra, and Nagar Haveli.

The NITTTR, Bhopal, is recognized as a centrally funded technical institution governed by the Department of Higher Education, Ministry of Education, Government of India. The Board of Governors, appointed by the Department of Higher Education (MoE), oversees the institute, representing various stakeholders, including the technical education system, industry, society, and the government. Based on recommendations from different review committees appointed by the Ministry of Education (formerly MHRD), the institute was upgraded and renamed as the "National Institute of Technical Teachers' Training and Research (NITTTR), Bhopal" in 2003 (Ministry letter no. F-7-27/2002-TS.IV dated 20 October 2003). This transformation expanded the institute's mandate, enabling it to function as a resource institution at the national and international levels for the entire spectrum of the technical education system.

The NITTTR, Bhopal, has evolved into a major resource institution and a center of excellence for the growth and expansion of the country's technical education system. It plays a crucial role in contributing to a diverse labor market beyond polytechnics and engineering colleges. The institute serves professional institutions, industry, public service organizations, vocational education, and the community at large, addressing their human resource development needs. NITTTR Bhopal has demonstrated its potential to cater to the training and development requirements of developing countries' technical education systems. Academically, it operates at the intersection of Technological, Pedagogical, and Content Knowledge areas.

NITTTR Bhopal has attained the status of a Deemed University (under the Distinct category) and is significantly contributing to implementing the National Education Policy 2020 in its true spirit. The institute is transitioning into a multidisciplinary institution of higher education, offering interdisciplinary programs that transcend traditional boundaries. All programs, courses, learning practices, and assessment mechanisms will have strong pedagogical underpinnings rooted in experiential learning, critical thinking, and problem-solving approaches. In line with NEP 2020's vision, NITTTR Bhopal aims to prepare self-driven, motivated educators with a learner-centric focus, incorporating a flexible multi-entry and multi-exit system across its diverse academic offerings.

## 2. Vision, Mission of The University

### 2.1 Vision Statement:

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.

### 2.2 Mission Statements:

- Incorporate principles of leadership in capacity building in technical teacher education through its courses encompassing future of work, green and sustainable development, women led development, development of faculty with diverse abilities and harnessing technology, etc.
- Provide leadership in technical teacher education that result in all technical faculty being made abreast with curriculum upgradation, future of work skills, pedagogy in the domain of technical teacher education.
- 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.

The Schools under the National Institute of Technical Teachers' Training & Research Bhopal, Deemed to be a University under a distinct category, are committed to providing a transformative educational experience aligned with NEP 2020 guidelines. It embraces a learner-centric approach with active participation. The schools are offering interdisciplinary Ph.D. for **in-service teachers, working professionals/ industry personnel, and enthusiastic learners** for capacity building and to enhance their professional skills.

The university comprises the following Schools:

- **School of Sciences:**
  i. Department of Applied Science Education (Physics, Chemistry)
- **School of Engineering and Technology:**
  i. Department of Civil& Environmental Engineering Education

ii. Department of Computer Science and Engineering Education
iii. Department of Electrical& Electronics Engineering Education
iv. Department of Mechanical Engineering Education

- **School of Management Studies:**
  i. Department of Management Education
- **School of Creative Education and Liberal Arts:**
  i. Department of Curriculum Development and Assessment Education
  ii. Department of Media Research and Development Education
  iii. Department of Technical Vocational Education & Research

## 3. School of Sciences

The School of Sciences is committed to providing a transformative educational experience aligned with NEP 2020 guidelines. It embraces a learner-centric approach with active participation. School of Sciences is comprised of the following department:

i. **Department of Applied Science Education**

The Department of Applied Science Education has existed since 1965 in the Institute. The Department is recognised for many significant contributions in training and research. With an orientation of interdisciplinary learning, the department promotes practical aspects of Applied Sciences. It offers various training programs in Physics, Mathematics, Chemistry, and Science education with practical applications in engineering and technology. The main focus of the research activities in applied sciences is theoretical and experimental, including Space Plasma Physics, Space Weather and Global Positioning Systems (GPS), Atmospheric Research in Antarctica/Arctic, Laser Physics, Free Electron Laser theory, Undulator characterisation, Nanoscience, Photoluminescent Nanomaterials, MEMS, Semiconductor package design, Sensors Technology, Physics Education, Chemical Sciences, Computer-Aided Drug Design, Drug Design, and Discovery, Nanomaterials, and Chemistry Education.

The department has contributed to various curriculum revision projects in Gujarat, Chhattisgarh, and Maharashtra in Physics, Chemistry, Mathematics, statistics, Chemical, Ceramic, Plastic, Textile, Surface coating, and Computer-Aided costume and dress design-making engineering. These curriculums align with NEP 2020 and are specially oriented to emerging technologies. The Department of Applied Science Education has also conducted several workshops, seminars, and national and international conferences for technical education teachers in the areas of science and engineering.

**Table 1: Department and Faculty**

| Schools | Department | Faculty |
|---|---|---|
| School of Sciences | Applied Science Education | Dr. P. K. Purohit |
| | | Dr. Bashirulla Shaik |
| | | Dr. Hussain Jeevakhan |

## 4. School of Engineering & Technology

Each department offers a multidisciplinary Ph.D. in emerging areas. The Ph. D. was coined in the interdisciplinary domain of knowledge creation among enthusiastic learners. All the engineering departments consist of faculties that are actively involved in industry-oriented research using the state of art facilities. All the departments are experts in designing and implementing outcome-based curricula, outcome-based teaching-learning, and outcome-based assessments. The faculty members carry out significant and sustainable research in every department. The enthusiastic learner can gain expertise in the chosen area through in-depth research and analysis.

A well-established centre of excellence, SEIMENS INDUSTRIAL AUTOMATION CENTRE provides smart, innovative equipment and software for advanced research. Every engineering department competently designs and develops new laboratory /virtual experiments. Every department collaborates with other departments or research centers to foster interdisciplinary research and innovation.

School of Engineering and Technology comprises the following departments:

1. Department of Civil & Environmental Engineering Education
2. Department of Computer Science and Engineering Education
3. Department of Electrical& Electronics Engineering Education
4. Department of Mechanical Engineering Education

### Table 2: Departments and Faculty

| Schools | Department | Faculty |
|---|---|---|
| School of Engineering and Technology | Civil & Environmental Engineering Education | Dr. A. K. Jain |
| | | Dr. Ramesh Gupta Burela |
| | | Dr. R. K. Dixit |
| | | Dr. V. D. Patil |
| | Computer Science and Engineering Education | Dr. M. A. Rizvi |
| | | Dr. R K. Kapoor |
| | | Dr. Rupesh Kumar Dewang |
| | | Dr. Sanjay Agrawal |
| | | Dr. S. Ganapathy |
| | Electrical Engineering Department of Electronics Engineering | Dr. Anjali Potnis |
| | | Dr. A. S. Walkey |
| | | Dr. C. S. Rajeshwari |
| | | Dr. Manickavasagam |
| | | Dr. Pallavee Bhatnagar |
| | | Dr. Ranjit Singh |
| | | Dr. Sachin Tiwari |

| Schools | Department | Faculty |
|---|---|---|
| | | Dr. Seema Verma |
| | | Dr. Suman Pattnaik |
| | Mechanical Engineering | Dr. A. S. Rocha |
| | | Dr. L. Suvarna Raju |
| | | Dr. Manish Bhargava |
| | | Dr. Ravi Kumar Gupta |
| | | Dr. Sharad K Pradhan |
| | | Dr. Vandana Somkuwar |
| | | Dr. Vipin Kumar Tripathi |

## 5. School of Management Studies

The School of Management Studies at NITTTR Bhopal provides a transformative educational experience. Our mission is to prepare learners to excel in the dynamic and intricate business world while nurturing future leaders, entrepreneurs, and scholars who can make meaningful contributions to society. The school fosters a culture of innovation, collaboration, and ethical leadership, challenging students to think critically, creatively, and responsibly. The Department of Management Education under the school offers a comprehensive range of Doctoral programs within the School of Management Studies. This includes emphasising leadership, policy analysis, and a **PhD in Management**. These programs cater to aspiring professionals and scholars, equipping them with the necessary knowledge and skills.

Additionally, the school is poised for growth, with plans to introduce two new departments: **Economics** and **Entrepreneurship**. These upcoming departments will further enhance our commitment to excellence in education, research, and community

The domain of Public Policy and Management is undergoing a transformative shift driven by the rapid pace of digital innovation. This field now encompasses careers that harness the power of technology and data to formulate, implement, and evaluate policies and strategies for effective governance and public service delivery. Professionals in this domain acquire interdisciplinary skills in digital policy analysis, e-governance, data analytics, and digital transformation management, enabling them to navigate the complexities of policymaking in an increasingly digitised world. With a deep understanding of the interplay between policy, technology, and societal dynamics, these professionals play a crucial role in promoting digital inclusion, enhancing transparency and accountability, and leveraging emerging technologies to address complex societal challenges. As governments and organisations embrace digital transformation, the demand for expertise in developing and executing digitally-enabled public policies and strategies has surged, opening up new career avenues for those with the necessary skills and knowledge.

### Table 3: Departments and Faculty

| Schools | Department | Faculty |
|---|---|---|
| School of Management Studies | Management Education | Dr. Aashish Deshpande |
| | | Dr. Parag Dubey |
| | | Dr. R. K. Dixit |
| | | Dr. Roli Pradhan |

## 6. School of Creative Education and Liberal Arts

The School of Creative Education and liberal Arts provides a research platform for technical teachers, researchers, industry persons, in-service teachers, and enthusiastic learners to build vocational, media, curriculum, and entrepreneurship development capacity. The departments provide research platforms for future AI, AR, and VR-based technologies, integrating them with industrial challenges to offer social and sustainable solutions in various fields. Another key area of the school is strengthening the enthusiastic learner linkages towards national and international agencies, universities, and industries to uplift the individual research domain. Some major research areas are Innovations in Curriculum Design & Development, Curriculum Implementation, Curriculum Evaluation, Impact Study of curriculum developed for different states, and Innovations in Assessment Practices, Social Media Management, Digital Content Resource Optimization, AI and Digital Media, Smart Journalism, Technology Integration and Pedagogical Development, Immersive Media, and MOOCs Effectiveness. Skill Development, Vocational, Quality Systems, Product Engineering and Design Thinking, Entrepreneurship Development, Engineering Education, Technical Education, Recognition of Prior Learning, Skill Gap Analysis

### Table 4: Departments and Faculty

| Schools | Department | Faculty |
|---|---|---|
| School of Creative Education and Liberal Arts | Curriculum Development and Assessment Education | Dr. Anju Rawlley |
| | | Dr. J. P. Tegar |
| | Media Research and Development Education | Dr. S. S. Kedar |
| | | Dr. Suman Pattnaik |
| | Technical Vocational Education& Research | Dr. A. K. Sarathe |
| | | Dr. Anjana Tiwari |
| | | Dr. Manish Bhargava |
| | | Dr. R. P. Khambayat |
| | | Dr. Ranjit Singh |
| | | Dr. Sachin Tiwari |
| | | Dr. Nishith Dubey |

## 7. Essential Qualification for Admission to the Ph.D.

**7.1 Table 5: Essential Qualifications**

| Schools | Department(s) | Major Thrust Areas | Essential Qualifications |
|---|---|---|---|
| School of Sciences | Applied Science Education | Space Plasma Physics, Space Weather and Global Positioning Systems (GPS), Atmospheric Research in Antarctica/Arctic, Laser Physics: Free Electron Laser theory, Undulator characterisation, Nanoscience: Photoluminescent Nanomaterials, MEMS, Semiconductor package design, Sensors Technology, Physics Education.<br>Chemistry, Computer Aided Drug Design, Drug Design and Discovery, Molecular Modelling, Computational Chemistry, Nanomaterials, Chemistry Education. | Master's degree in relevant stream of Science with 55% or equivalent CGPA. |
| School of Engineering and Technology | Civil and Environmental Engineering Education | Highway Materials, Soil-Structure Interaction, Multifunctional smart composites, computational solid mechanics, AI & ML in CAE, Urban and Regional Planning, Sustainable Development and Environmental Planning, Land Economics and Valuation, Urban Renewal and Redevelopment, Real Estate Development and Management, Infrastructure Planning and Financing | Master's degree in relevant stream of Engineering/Technology with 55% or equivalent CGPA. |
| | Computer Science and Engineering Education | AI & ML, Cyber Security, Adhoc Networks, Blockchain Technology, Data Science, Big Data Analytics, Data Engineering, Cloud Computing, Data Security, Image Processing, Real-Time Systems, Software Engineering, Green Computing, Grid Computing, Bioinformatics, Internet of | |

| Schools | Department(s) | Major Thrust Areas | Essential Qualifications |
|---|---|---|---|
| | | Things, Educational Approaches using emerging computing technologies. | |
| | Electrical & Electronics Engineering Education | Renewable Energy Systems, Smart Grid Technologies, Power System Control, system optimization, Power System Restructuring, Low Voltage Switch Gear, Electric Vehicle Technology, Multi Level Inverters, Power Converters, Power Quality Improvement, Drives and Control Power Converters, Industrial Drives, Artificial Intelligence and Machine Learning applications to Power Systems, Artificial Intelligence and Machine Learning applications to Power Electronics, Digital Twin, Industrial Automation, Electrical and Energy studies, Hydrogen fuel cells, Battery technology. Wireless Networking, Flying Adhoc Networks & their VLSI implementation, Smart agriculture system using Drone, VLSI for AI, Digital Twin, Semiconductor Technology, Semiconductor Packaging, 5G -6G Communication, IoT, Image and Signal Processing, Digital Signal Processing, Evolutionary Computing, Antenna Design, Biomedical Signal Processing, Deep Learning/CNN and its Application. | |
| | Mechanical Engineering Education | Additive Manufacturing, Green Manufacturing, Advanced Composite Materials, Computer Aided Design and Manufacturing, Design Optimization, Friction stir welding and Process, Industrial Design, Product Development for Elderly, Product Informatics, Robotic Welding. | |

| Schools | Department(s) | Major Thrust Areas | Essential Qualifications |
|---|---|---|---|
| School of Management Studies | Management Education | Management, Human Resources, Marketing, Finance, Education Management, Business Analytics, Green Technology, Econometrics, Social Interventions& Entrepreneurship, Public Policy | Master's degree in relevant stream with 55% or equivalent CGPA. |
| School of Creative Education and Liberal Arts | Curriculum Development and Assessment Education | Innovations in Curriculum Design & Development, Curriculum Implementation, Curriculum Evaluation, Impact Study of curriculum developed for different states, Innovations in Assessment Practices. | Master's degree in any stream of discipline with 55% or equivalent CGPA. |
| | Department of Media Research and Development Education | Social Media Management, Digital Content Resource Optimization, AI and Digital Media, Smart Journalism, Technology Integration and Pedagogical Development, Immersive Media, and MOOCs Effectiveness. | |
| | Technical Vocational Education & Research | Skill Development, Vocational, Quality Systems, Product Engineering and Design Thinking, Entrepreneurship Development, Engineering Education, Technical Education, Recognition of Prior Learning, Skill Gap Analysis | |

## 8. Admission Procedure

Admission to the PhD programme involves a rigorous selection process, ensuring that qualified candidates join the vibrant academic community at the university. Admission to the Ph. D. programme will be given through the following process:

**a)** NITTTR Bhopal shall notify predetermined seats (reservation of seats will be as per the Govt. of India norms). The vacant seats, if any, out of category-I candidates shall be filled through the Entrance Test (category-2).

**b)** The admission process will be through the following two categories:

**Category-1:**

A candidate who qualifies either of the following is considered for admission process under exempted from the entrance test, and based on the interaction (Total Marks – 50), a merit list will be prepared to mention selected/Not selected candidates:

i. UGC-JRF or Joint CSIR-UGC JRF in the main subject (with validity period).
ii. UGC-NET or Joint CSIR-UGC-NET/UGC NTA/Teacher Fellowship holder/ DST Inspire fellow (with validity period) in the main Subject.
iii. GATE (with validity period)/ GPAT (with validity period) in the main subject.

**Category-2:**

i. 50% weightage of the entrance test marks (Maximum 50 Marks, minimum 25 marks are required to qualify)
ii. 20% weightage will be given to experienced candidates having a maximum of 4 years of experience. Only completed years will be counted on the last date of application form submission, five marks for each year of experience. (Maximum 20 Marks)
iii. 30% weightage will be given on the basis of a statement of purpose for a PhD and a Personal Interview. (Maximum 30 Marks)

Based on the merit and reservation criteria, the vacant seats will be offered to the candidates.

**c)** The vacant seats, if any, out of category-1 candidates shall be filled through the Entrance Test (category-2). There will be single entrance test for Main and Allied Subjects in each Department.

**d)** The admission under category-2 (Through Entrance Test) shall be made in order of merit and preference, subject to availability of seats and experts for guidance /supervision in the area of Research on the recommendation of admission committee.

**e)** A candidate may apply for admission to Ph.D. Course (through Entrance Test) in the main subject (in which he/she has passed his/her Master's Degree) as well as allied subjects, if any.

**f)** NITTTR Bhopal shall hold Entrance Test as per schedule notified subject to availability of seats in each department.

**g)** The Entrance Test Paper will consist of Objective type questions as per following scheme:

Marks: 100
Number of MCQ Questions: 100
Total Duration: 2 (Two) hours.

**h)** The syllabus of the Entrance Test shall consist of up to 50% of Research methodology and remaining shall be subject specific. Syllabus of the Entrance Test will be available on the university website. There shall be no negative marking.

**i)** The candidate will be required to secure 50% marks in Entrance Test for being eligible for consideration to Ph. D. programme.

**j)** There will be no provision for re-evaluation of answer books for the paper of Ph.D. Entrance Test.

## 9. Fee Structure for Ph. D.

| S. No. | Description | Fees (in Rs.) | Payable |
|---|---|---|---|
| 1. | Tuition Fees | 8,000 /-<br>25,000/- For Sponsored Candidates | **Per Semester** |
| 2. | Student Welfare Fund | 600/- | |
| 3. | Student Medical Fund | 400/- | |
| 4. | Institute Development Fund | 2500/- | |
| 5. | Student Activity fee | 1000/- | |
| 6. | Library Fee | 1000/- | |
| 7. | Central Computing Facilities, Internet Fee, | 1500/- | |
| **At the Time of Admission (Non-Refundable)** | | | |
| 8. | Academic Fee (Including Degree, Migration, Character, ID card): Onetime fee | 2000/- | **One Time Fee** |
| 9. | Industry Immersion Programme | 3000/- | |
| 10. | Convocation fee | 2000/- | |
| 11. | Alumni fee | 1000/- | |
| 12. | Enrollment Fee: Registration, Course Work and Examination Fee | 8,000/- | |
| 13. | Student Insurance Fee. | 300/- | **Per annum** |
| **At the Time of Thesis Submission and Evaluation (Non-Refundable)** | | | |
| 14. | Thesis Submission and Evaluation | 20,000 | **One Time Fee** |
| **At the Time of Admission (Refundable)** | | | |
| 15. | Caution money | 5000/- | **One Time Fee** |

The admitted student must deposit the semester fees through the institute web portal/payment gateway. In addition to the above-mentioned fee, the candidate must deposit hostel lodging and boarding charges as per the norms before the start of the semester.

## 10. Admission Schedule

The category-wise (category 1 and 2) admission schedule will be posted on the Institute's website. Candidates are advised to check the website (www.nitttrbpl.ac.in) regularly for updates.

## 11. Fellowship/Scholarship

Candidates with valid score of qualifying examination will be offered essential fellowship/ scholarship as per the rule of government of India.

## 12. Hostel Accommodation

Hostel accommodation is available based on the merit of admission to the candidates. Preference will be given to outstation candidates. If the accommodation is further available, the local candidates may also be considered for hostel accommodation.

## 13. Hostel Fee Details

| S. No | Room Category | Fee Per Semester | Remark |
|---|---|---|---|
| 1. | Single Occupancy Non-AC (per person) | 6000/- | Subjected to the availability |
| 2. | Double Occupancy Non-AC (per person) | 4000/- | |
| 3. | Single Occupancy AC with attached toilet | 72000/- | |
| 4. | Double Occupancy AC with attached toilet (per person) | 40000/- | |
| 5. | Hostel Maintenance Fee (Electricity, Water, Sanitation | 10500/- | |

## 14. Ph.D. Coursework - Curricula

**Common Courses for all Schools:**

- **Research Methodology**
- **Research and Publication Ethics**
- **Research Seminar**

**School wise Courses:**

- **Curriculum and Assessment**
- **Educational Media Development and Studies**
- **Technical & Vocational Education Studies**
- **Finite Element Analysis**
- **Artificial Intelligence & Machine Learning**
- **Soft Computing**
- **Computer Aided Design and Analysis**
- **Digital Manufacturing**
- **Optimization and Simulation**
- **Advances in Management**

| | |
|---|---|
| **A)** | **Course Title: Research Methodology** |
| **B)** | **Course Code: PhD-RM** |
| **C)** | **Pre-requisite course (s):** |

**D) Rationale:** The Research Methodology course is designed for pre-Ph.D. students to equip them with essential skills in scientific inquiry and academic research, forming the foundation of their doctoral studies. This course provides a structured approach to understanding research processes, from formulating problems to choosing appropriate methodologies and analysing data effectively. Doctoral students are expected to contribute original knowledge to their fields, and this course emphasises critical aspects such as literature review, critical thinking and logical reasoning, problem formulation, designing of experiments, data analysis and interpretation, thesis writing, scientific writing and presentation skills. By fostering skills in qualitative and quantitative research, students will gain a comprehensive understanding of rigorous, ethical, and impactful research practices crucial for addressing complex, real-world challenges within their disciplines.

**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 |
|---|---|
| CO1 | Create flowcharts outlining the scientific research processes for various research-oriented problems. |
| CO2 | Develop comprehensive sets of research questions for various research problems. |
| CO3 | Write structured literature reviews, synthesizing information from multiple sources. |
| CO4 | Analyze outcomes of various data analysis, interpreting results of various statistical tests. |
| CO5 | Create various research reports in appropriate formats. |

## F) Teaching & Learning and Assessment Scheme:

| Board of Study | Course Category and Code | Course Titles | Teaching & Learning Scheme (Hours/Week) | | | | | | Assessment Scheme (Marks) | | | | | | Total Marks (TA+TWA+LA) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Theory Component (TC) | | Lab Instruction (LI) | Term Work/Self Learning (TW/SL) | Total Hours/Week (TC+LI+TW/SL) (For 15 Weeks) | Total Credits | Theory Assessment (TA) | | Term work 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) | |
| | **PhD-RM** | **Research Methodology** | **04** | | | **04** | **08** | **04** | **25** | **50** | **15** | **10** | **-** | **-** | **100** |

**G) Course Curriculum Detailing:** For the attainment of course outcomes, the students are expected to perform/ undergo various activities through classroom/seminar/self-learning/ field sessions. As per the requirements of NEP 2020.

## H) Theory Session Outcomes (TSOs) and Units:

| Major Theory Session Outcomes (TSOs) | Units | Relevant CO Number(s) |
|---|---|---|
| *TSO 1a.* Outline the significance in academia and Industry.<br>*TSO 1b.* Explain the various types of research, such as descriptive, analytical, applied, and fundamental.<br>*TSO 1c.* Outline the critical steps involved in the research process.<br>*TSO 1d.* Explain the importance of each quality, including originality, reliability, validity, and objectivity, in research.<br>*TSO 1e.* Explain the role of research in addressing societal challenges and advancing knowledge. | **Unit-1.0 Fundamentals of Research**<br>1 1. Definition and significance of research in academia and industry.<br>1 2. Objectives, motivation, and types of research: Descriptive, Analytical, Applied, Fundamental, Quantitative, Qualitative, Conceptual, and Empirical Research Approaches<br>1 3. Research Process: Scientific research characteristics and steps of scientific research, Scientific research problems<br>1 4. Qualities of good research: Originality, Reliability, Validity, and Objectivity<br>1 5. Role and applications in practice development and policy formulation. | CO1 |
| *TSO 2a.* Develop research questions based on a given problem statement.<br>*TSO 2b.* Apply techniques of problem definition to a hypothetical research scenario.<br>*TSO 2c.* Differentiate various research designs in terms of strengths and weaknesses. | **Unit-2.0 Research Design and Methodology**<br>2.1 Research Problem and Research Questions,<br>2.2 Research Design: Problem Definition, Techniques of problem defining, Key components (Independent, dependent, extraneous, control). | CO2 |

| Major Theory Session Outcomes (TSOs) | Units | Relevant CO Number(s) |
|---|---|---|
| *TSO 2d.* Select an appropriate research design for a given research scenario and justify the choice.<br>*TSO 2e.* Apply the concept of research methodology to outline a basic research framework. | 2.3 Purpose of Research design process, Errors in Research, Basic Principles of Experimental Designs, Design of Experiments.<br>2.4 Types of Research Designs: Experimental, non-experimental (true experimental, quasi-experimental, ethnography, grounded theory, action research, mixed methods approach, Exploratory, Descriptive, observational designs), Comparative study and Case study method etc.<br>2.5 Research Methods versus Methodology: Roles and Framework. | |
| *TSO 3a.* Explain the importance of a literature review in the process of defining a research problem.<br>*TSO 3b.* Use various sources of literature to collect information relevant to a specific research topic.<br>*TSO 3c.* Analyze different types of literature to determine their relevance and usefulness in a research context.<br>*TSO 3d.* Develop a plan for conducting a literature review using identification, evaluation, and synthesis.<br>*TSO 3e.* Write the step by step process of identifying research gaps from existing literature. | **Unit-3.0 Literature Review**<br>3.1 Review of Literature: Introduction, Objectives, Purposes of Review of Literature, Importance of Literature Review in Defining a Problem,<br>3.2 Sources of Literature: Primary, secondary, and tertiary sources of literature (Journals and Books, Reviews, Abstracts, Indexes, Internet, Doctoral Dissertations),<br>3.3 Types of Literature: Argumentative, integrative, historical, methodological and theoretical review (Subject Specific Books, Grey Literature, Official Publications, Journal Articles, literature review-primary and secondary sources, reviews, monographs, patents.<br>3.4 Conduct Literature Review: Identify, evaluate, synthesize and write<br>3.5 Identifying gap areas from the literature review, Factors affecting literature review. | CO3 |
| *TSO 4a.* Apply different sampling techniques to collect data for a research study.<br>*TSO 4b.* Formulate a null hypothesis and set up a hypothesis testing process using a flow diagram.<br>*TSO 4c.* Use statistical packages such as SPSS or R to perform quantitative data analysis, such as regression or ANOVA.<br>*TSO 4d.* Conduct a basic factor or cluster analysis using real or hypothetical data sets.<br>*TSO 4e.* Apply thematic analysis to interpret a qualitative data set. | **Unit-4.0 Sampling, Data analysis and Interpretation:**<br>4.1 Data Sampling Techniques or Methods, Concept and Importance, Choice of Sampling Techniques. Population and Sampling: Sampling techniques (probability and non-probability sampling.<br>4.2 Normal Distribution, Central Tendency, Standard Deviation, Variance, correlation, regression (Linear and Multiple)<br>4.3 Hypothesis: Definition, Characteristics, Types, null hypothesis, hypothesis | CO4 |

| Major Theory Session Outcomes (TSOs) | Units | Relevant CO Number(s) |
|---|---|---|
| *TSO 4f.* Create charts and tables to represent research data clearly using data visualization tools. | testing, flow diagram for hypothesis testing.<br>4.4 Data Analysis: Quantitative data analysis: student "t" distribution, Chi-square distribution, ANOVA, Descriptive statistics, classification and use of statistical packages. (Open-source softwares) Multivariate Analysis: Factor analysis, cluster analysis, discriminator analysis.<br>4.5 Qualitative data analysis: Thematic analysis, content analysis.<br>4.6 Data Interpretation and Visualization: Data visualization tools, tables, charts, and best practices for clear and effective presentation. | |
| *TSO 5a.* Differentiate between various types of research reports.<br>*TSO 5b.* Apply the steps in writing a research report to draft a layout for a specific research project.<br>*TSO 5c.* Develop a research proposal using the proper structure, including an introduction and literature review.<br>*TSO 5d.* Use a referencing tool like Mendeley or Zotero to create a bibliography in a chosen citation style.<br>*TSO 5e.* Prepare an oral presentation plan using visual aids and communication techniques. | **Unit -5.0 Academic Writing and Presentation**<br>5.1 Research reports: Introduction, Classification of research reports (Long, Short, Monograph, Journalistic, business, Project, Dissertation, Enquiry, Technical, reports and thesis.<br>5.2 Research Report Writing: Interpretation, Meaning, techniques, Significance, Different steps in writing a research report and the preparation Layout.<br>5.3 Research Proposal Writing: Structure of a research proposal: title, abstract, introduction, literature review, research design, and references.<br>5.4 Academic Writing and Referencing: Bibliography, referencing, Citation and referencing styles (APA, MLA, Chicago, etc.), Referencing tools (EndNote, Mendeley, Zotero, End Note).<br>5.5 Presenting of Research Findings: Oral presentations and defence preparation techniques: Planning, Preparation, Practice, Making presentation, Use of visual aids, Importance of effective communication, Use of ICT tools in research | **CO5** |

**I) Suggested Laboratory Experiences: NA**

**J) Suggested Research Based Problems: NA**

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

**a. Assignment(s):**

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

1. Differentiate between various research types (Descriptive, Analytical, Applied, Fundamental, Quantitative, Qualitative, Conceptual, and Empirical). Provide examples of each type and explain the scenarios where each type of research is most applicable.
2. Analyze the components of a research design (independent, dependent, extraneous, and control variables) and their importance in conducting a practical study. Illustrate with examples how each component affects research outcomes.
3. Compare and contrast different types of research designs, including experimental and non-experimental (ethnography, action research, mixed methods, etc.). Explain their suitability for different research objectives and provide case studies as examples.
4. Conduct a literature review on a chosen topic, identifying primary, secondary, and tertiary sources. Summarise your findings and identify gaps that could form the basis for future research.
5. Perform quantitative data analysis using any of the following: t-test, Chi-square test, ANOVA, or regression analysis. Present your findings using statistical software and interpret the results.
6. Create a research report or proposal on a selected topic. Include sections like title, abstract, introduction, literature review, research design, and references.
7. Identify a gap in research within a specific academic or industrial field. Formulate a research problem and propose a study that addresses this gap, detailing the significance and expected outcomes.
8. Design a research study to investigate the effectiveness of a new teaching method. Define your research problem, select an appropriate research design, and explain your choice of variables.
9. Conduct a literature review on a current issue in your field. Identify critical themes, synthesize findings, and propose future research directions based on identified gaps.
10. Perform a data analysis using a chosen dataset. Use statistical software like SPSS or R to conduct regression analysis or ANOVA and interpret the results.
11. Create visualisations for a given dataset using data visualization tools. Discuss the effectiveness of different visualisation methods in presenting research findings.
12. Write a research proposal on a topic of your choice. Following academic writing conventions, include a literature review, research design, methodology, and expected outcomes.

**b. Seminar Topics:**

- The Role of Research in Advancing Academia and Industry: Opportunities and Challenges.
- Sampling Techniques: Choosing the Right Method for Your Research
- Literature Review
- Multivariate Analysis in Research: Applications and Techniques
- AI ML in Research
- Best Practices and ICT Tools – Explore strategies for delivering impactful research

**L) 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 Fundamentals of Research | 08 |
| CO2 | Unit 2.0 Research Design and Methodology | 12 |
| CO3 | Unit 3.0 Literature Review | 10 |
| CO4 | Unit 4.0 Sampling, Data Analysis and Interpretation | 10 |
| CO5 | Unit 5.0 Academic Writing and Presentation | 10 |
| **Total** | | **50** |

**M) 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, case method, group discussions, industrial visits, industrial training, field trips, portfolio based, learning, role play, live demonstrations in classrooms, labs, field information and communications technology (ICT) based teaching learning, blended or flipped mode, brainstorming, expert session, video clippings, use of open educational resources (OER), MOOCs etc. To ensure learning, research-based problems may be designed and implemented.

**N) Major Equipment, Tools and Software for Laboratory and Research Work:** NA

**O) Suggested Learning Resources:**

**a) Books**

| S. No. | Titles | Author(s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 1. | Research Methodology Techniques and Trends | Umesh Kumar Bhayyalal Dubey, D. P. Kothari | Boca Raton: Chapman & Hall/CRC Press, 2022 ISBN 9781138053984 (hardback) |
| 2. | Research Methodology: Methods and Techniques | C. R. Kothari, Gaurav Garg | 5th Edition, New Age International Publishers, ISBN 9789389802559 |
| 3. | Advanced Research Methodology | R Barker Bausell | Scarecrow Press, 1991, ISBN 9780810823556 |
| 4. | Research Methodology | S.C. Sinha , A. K. Dhiman | Ess Ess Publications, 2002, ISBN 8170003245 |
| 5. | Research Methods: The Concise Knowledge Base. | W. M. Trochim. W. M .K. | Atomic Dog Publishing. 270p., 2005 ISBN 1592601456 |
| 6. | An Introduction to Research Methodology. | Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U. K. | RBSA Publishers, 2015, ISBN: 9788176111652, 8176111651 |
| 7. | How to Write and Publish a Scientific Paper | Day R.A. | Cambridge University Press ISBN 978-1-107-67074-7 |

| S. No. | Titles | Author(s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 8. | Practical Research: Planning and Design | Paul Leedy Jeanne | 12th Edition, 2018, Prentice Hall ISBN 978-0134775654 |
| 9. | Research Methodology: An Introduction | Wayne Goddard, Stuart Melville | 2007, Juta and Co. Ltd. ISBN 9780702156601 |
| 10. | Research Methodology: A Guide for Researchers in Management and Social Sciences | Bill Taylor, Gautam Sinha, Taposh Ghoshal. | Prentice-Hall of India Private Limited, New Delhi. 2006 ISBN: 9788120329911 |
| 11. | Qualitative data analysis: A Methods Sourcebook | Miles, M.B., Huberman, A.M., Saldana, J. | Third Edition, SAGE publications, 2014 ISBN 9781452257877 |
| 12. | Research design: Qualitative, Quantitative, and Mixed Methods Approaches | John W Creswell, J. David Creswell | 5th ed., Thousand Oaks, CA: Sage 2019, ISBN: 9789353287351 |
| 13. | The Essence of Research Methodology: A Concise Guide for Master and PhD Students in Management Science. | Jonker Jan, Pennink Bartjan. | 2010 , Springer Berlin, Heidelberg . ISBN 978-3-540-71658-7 |

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

1) https://onlinecourses.nptel.ac.in/noc23_ge36
2) https://ugcmoocs.inflibnet.ac.in/index.php/courses/view_ug/330
3) https://onlinecourses.swayam2.ac.in/ugc19_ge03
4) https://onlinecourses.swayam2.ac.in/ugc19_ma05
5) https://www.courseera.org/learn/research-methodologies
6) https://www.sjsu.edu/writingcenter/docs/handouts/Literature%20Reviews.pdf
7) https://southcampus.uok.edu.in/Files/Link/DownloadLink/RM%20U1%20P1.pdf
8) https://www.r-project.org
9) https://www.mendeley.com
10) https://www.zotero.org

## P) Course Curriculum Development Team

| S. No. | Name and Designation | E-mail Address |
|---|---|---|
| 1. | Dr. Bashirulla Shaik | bshaik@nitttrbpl.ac.in |
| 2. | Dr. Roli Pradhan | rpradhan@nitttrbpl.ac.in |
| 3. | Dr. K Manikavasagam | kmanikavasagam@nitttrbpl.ac.in |

| | | |
|---|---|---|
| **A)** | **Course Title:** Research and Publication Ethics | |
| **B)** | **Course Code: PhD-RP** | |
| **C)** | **Pre- requisite Course (s):** | |

**D) Rationale:** Research ethics form the cornerstone of responsible and credible scientific inquiry, ensuring that research is conducted with integrity, fairness, and respect. The primary rationale for research ethics is to uphold the integrity and credibility of scientific work. Ethical research practices ensure that data collection, analysis, and reporting are honest, accurate, and transparent, preventing issues such as falsification, plagiarism, or misrepresentation that undermine the trustworthiness of findings. This also ponders on another critical aspect of research ethics is the protection of participants' rights and welfare.

Ethical research also aligns with the principle of social responsibility. Researchers are expected to contribute positively to society by addressing relevant issues and advancing knowledge that benefits humanity. Fairness is another key rationale for research ethics. Ethical guidelines ensure that all contributors to a research project are acknowledged appropriately and that conflicts of interest are disclosed to prevent biased outcomes. Fairness fosters trust and mutual respect among researchers, funding bodies, and institutions in collaborative environments. Additionally, adherence to ethical standards ensures compliance with laws, regulations, and professional codes, providing accountability and protecting intellectual property rights. Finally, ethical research facilitates reproducibility and peer review by maintaining accurate records, sharing methodologies openly, and allowing verification of results. This contributes to the cumulative advancement of knowledge and scientific discovery. This course deals with the fundamentals and principles of research ethics, covering topics like the nature of the research, potential risks in research, the legalities of publication, and the rights associated with publications in research. The course intends to focus on adhering to ethical principles, researchers upholding the credibility of their work, fostering collaboration, and ensuring that their efforts contribute positively to society and the broader scientific community.

**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 |
|---|---|
| **CO1** | Apply ethical principles for the evaluation of various research publications. |
| **CO2** | Identify the publication misconducts, complaints and appeals in various research publications. |
| **CO3** | Apply journal finder/journal suggestion tools to select journals for various publications. |
| **CO4** | Use plagiarism software like Turnitin/Urkund/Grammarly and other open- |

| | |
|---|---|
| | source software tools to analyze plagiarism in research. |
| **CO5** | Identify the indexing databases for the given research. |

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

| Board of Study (BOS) | Course Code | Course Category | Course Titles | Teaching & Learning Scheme (Hours/Week) | | | | | | Assessment Scheme (Marks) | | | | | | Total Marks(TA+TWA+LA) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Theory Component (TC) | | Lab Component (LC) | Term Work (TW) and Self Learning (SL)(TW+SL) | Total Hours/Week (I+T+LC+TW+SL) | Total Credits (C) | Theory Assessment (TA) | | Term work & Self-Learning Assessment (TWA) | | Lab Assessment (LA) | | |
| | | | | Input (I) | Tutorial (T) | | | | | Progressive Theory Assessment (PTA) | End Term Theory Assessment (ETA) | Progressive Term Work Assessment (PTWA) | End Term Work Assessment (ETWA) | Progressive Lab Assessment (PLA) | End Term Laboratory Assessment (ELA) | |
| **Education Technology (ET)** | **PC01** | **PC** | **Research & Publication Ethics** | **02** | **-** | **-** | **02** | **04** | **02** | **15** | **25** | **10** | **-** | **-** | **-** | **50** |

**G) 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.

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

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| *TSO 1a.* Outline the vital aspects of philosophy and ethics in the given research.<br>*TSO 1b.* Identify the boundaries and extent of the given study.<br>*TSO 1c.* Identify a category, idea, or phenomenon for conceptual development of the given research.<br>*TSO 1d.* Identify the branch wrt specific applications, subfields, or specialized areas emerging from a central concept in the given research.<br>*TSO 1e.* Determine the moral values, principles, and rules to be adhered for action in the given situation. | **Unit-1.0 Philosophy, Ethics and Scientific Conduct**<br>1.1 Introduction to Philosophy.<br>1.2 Definition, nature and scope.<br>1.3 Concept and Branches of Philosophy.<br>1.4 Ethics: Definition, moral philosophy<br>1.5 Nature of moral judgments and reactions<br>1.6 Ethics with respect to science and research<br>1.7 Intellectual honesty and research integrity.<br>1.8 Scientific misconducts: Falsification, Fabrication and Plagiarism (FFP). | **CO1** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| *TSO 1f.* Evaluate the rightness or wrongness of actions, decisions, or character for the given situation.<br>*TSO 1g.* Explain moral principles and guidelines governing the conduct of scientific inquiry and the application of research findings for the given research.<br>*TSO 1h.* Identify truthfulness, transparency, and ethical conduct throughout the given research process.<br>*TSO 1i.* Explain unethical behavior that undermines the integrity of the given research process.<br>*TSO 1j.* Examine the parameters of cautiousness to be adopted while disseminating the given same research findings multiple times across different publications.<br>*TSO 1k.* Inspect unethical practices involving manipulation or distorted presentation of research findings that diminish the sanctity of the given results | 1.9 Redundant publications: duplicate and overlapping publications, salami slicing<br>1.10 Selective reporting and misrepresentation of data. | |
| *TSO 2a.* Illustrate the conduct of individuals involved in the publication process of the given research.<br>*TSO 2b.* Infer best practices/standards setting initiatives and guidelines.<br>*TSO 2c.* Explain the role of individual's personal or professional interests that potentially influence their objectivity in conducting, reviewing or publishing the given research.<br>*TSO 2d.* Outline the unethical behaviors and practices related to the process of publishing the given scientific research.<br>*TSO 2e.* Write proper authorship and acknowledgment for maintaining the integrity of scholarly communication for the given research work.<br>*TSO 2f.* Identify the publication misconduct, complaints and appeals in research.<br>*TSO 2g.* Identify the unethical entities that exploit the open-access publishing model for financial gain without providing legitimate peer review or editorial services. | **Unit-2.0 Publication Ethics**<br>2.1 Publication ethics: definition, introduction and importance<br>2.2 Best practices/standards setting initiatives and guidelines: COPE, WAME etc.<br>2.3 Conflicts of interest<br>2.4 Publication misconduct: Definition, concept, problems that lead to unethical behaviour and vice versa, types<br>2.5 Violation of publication ethics, authorship and contributor ship<br>2.6 Identification of publication misconduct, complaints and appeals<br>2.7 Predatory publishers and journals | **CO2** |
| *TSO 3a.* Explain the role of the open access publications in increasing the dissemination of research findings, enabling a wider audience. | **Unit-3.0 Open Access Publishing**<br>3.1 Open access publications and initiatives | **CO4** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| *TSO 3b.* Identify the online resources that provides information on publisher copyright and self-archiving policies using SHERPA/RoMEO<br>*TSO 3c.* Identify predatory publications using software tool developed by SPPU: UGC-CARE list of journals<br>*TSO 3d.* Apply journal finder/journal suggestion tools to select proper journals for publication. | 3.2 SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies<br>3.3 Software tool to identify predatory publications developed by SPPU: UGC-CARE list of journals<br>3.4 Journal finder/journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc. | |
| *TSO 4a.* Develop an approach to addressing ethical challenges through group discussion on the given topics.<br>*TSO 4b.* Use the plagiarism software like Turnitin/ Urkund/Grammarly and other open source software tools to analyze the plagiarism in research. | **Unit 4: Publication Misconduct**<br>4.1 Group Discussion:<br>a) Subject-specific ethical issues, Falsification, Fabrication and Plagiarism (FFP), authorship<br>b) Conflicts of interest<br>c) Complaints and appeals: examples and fraud from India and abroad<br>4.2 Software tools: Use of plagiarism software like Turnitin/Urkund/Grammarly and other open source software tools. | **CO5** |
| *TSO 5a.* Identify the indexing databases for the given research.<br>*TSO 5b.* Use citation databases: Web of Science, Scopus, etc. for the given research.<br>*TSO 5c.* Calculate Impact Factor of journal as per Journal Citations Report, SNIP, SJR, IPP, Cite Score<br>*TSO 5d.* Identify Metrics: h-index, g index, i10 Index, Altmetrics | **Unit 5: Databases and Research Metrics**<br>5.1 Databases: Indexing databases<br>5.2 Citation databases: Web of Science, Scopus, etc.<br>5.3 Research Metrics: Impact Factor of journal as per Journal Citations Report, SNIP, SJR, IPP, Cite Score<br>5.4 Metrics: h-index, g index, i10 Index, Altmetrics. | |

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

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

Ethics in science and research refers to the moral principles and guidelines that govern the conduct of scientific inquiry and the application of research findings. These ethical standards are crucial for ensuring the integrity, credibility, and social responsibility of scientific endeavors. Ethics in research addresses issues such as honesty, objectivity, respect for intellectual property, and the protection of human and animal subjects.

This part of the task is structured to test the researcher's skill on ethical standards ensure that research is conducted with honesty and transparency. Researchers are expected to report data truthfully, avoid falsification or fabrication of results, and acknowledge the contributions of others.

- Identification of relevant topic and determine the retracted paper
- Analyse notice of retraction in the retracted paper
- Generate report with justification for retraction

## K) Suggested Term Work (TW) and Self Learning (SL):

**a) Assignment(s):**

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

- Calculate and compare impact factor and h-index for journals in their field
- Read and understand the author instructions for journal publication of SCI/Scopus indexed journal
- Calculate and analyse cite score of relevant journals
- Usage of AI tools (open source and subscripted software) in research activity. Connected papers, Scite_, etc
- Usage of journal finder to select appropriate journal for your research work
- Analyse the copyright aspects of a set of journals
- The Importance of Research Ethics in Scientific Inquiry: Write a 1000-word essay discussing the significance of research ethics in ensuring credible and responsible research practices. Provide examples of ethical dilemmas in research.
- Historical Cases of Ethical Misconduct in Research: Analyze a historical case and explain the ethical violations involved. Discuss the implications and lessons learned.
- Review a real-world scenario involving ethical issues in research (e.g., data falsification or informed consent violation). Analyze the ethical challenges, propose solutions, and discuss preventive measures.
- Develop a Code of Ethics: Ask students to design a code of ethics for a specific field (e.g., medical research, social sciences, or environmental studies). Present it as a group with justifications for each ethical guideline.
- Ethical Review Board Simulation: Assign roles as researchers and ethics board members. Students propose a research project, and the "board" evaluates its ethical implications before granting approval.
- Investigate Ethical Guidelines: Research the ethical guidelines of organizations like the APA, WHO, or NIH. Compare them with national research ethics guidelines and write a summary of similarities and differences.
- Ethical Implications of Emerging Technologies: Write a research paper exploring the ethical challenges posed by technologies like AI, CRISPR, or big data analytics.
- Plagiarism Detection and Prevention: Provide examples of text with potential plagiarism. Ask students to identify the issues and rewrite them to meet ethical standards.

**b) Seminar Topics:**

- Conflict of Interest in Research: Identification and Management
- Data Integrity and Fabrication in Research
- Big Data Ethics: Privacy and Consent
- Ethical issues in interviews, surveys, and participant observation.
- Environmental Ethics in Scientific Research
- Ethics in Clinical Trials: Balancing Innovation and Participant Safety
- Tools and techniques to integrate ethics into research proposals.
- The Role of Institutional Review Boards (IRBs) in Ethical Research
- Building a Culture of Ethics in Research Organizations
- Encouraging ethical behavior at the institutional level.
- Analyzing real-world cases of ethical violations and their resolutions.

- Frameworks and tools for navigating ethical dilemmas.
- Intellectual Property Rights and Ethical Research
- Debates on controversial studies and their societal impact.
- The Role of Whistleblowers in Maintaining Ethical Standards
- The Dark Side of Innovation: Ethical Challenges in Cutting-Edge Research
- PhD research work

**c) Self-Learning:**

- Foundational Principles of Research Ethics
- Autonomy, beneficence, non-maleficence, and justice in research.
- Identifying ethical dilemmas in published research and proposing solutions.
- Creating Your Personal Code of Research Ethics
- Self-Auditing Research Practices
- Techniques for evaluating your compliance with ethical standards.
- Specific Ethical Challenges
- Handling sensitive data responsibly and ensuring participant anonymity.
- Ethics of Authorship and Publication
- Utilizing AI-powered platforms for ethical training and decision-making.
- Self-Learning Ethical Challenges in Big Data Research
- Key Research Ethics Documents for Self-Learning
- Developing Ethical Resilience in Research

**L) 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 Philosophy, Ethics and Scientific Conduct | 5 |
| CO2 | Unit 2.0 Publication Ethics | 5 |
| CO3 | Unit 3.0 Open Access Publishing | 5 |
| CO4 | Unit 4.0 Publication Misconduct | 5 |
| CO5 | Unit 5.0 Databases and Research Metrics | 5 |
| **Total** | | **25** |

**M) 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. To ensure learning, micro project, research-based problems etc may be designed and implemented.

**N) Major Equipment, Tools and Software for Laboratory and Research Work:** NA

- Grammarly plagiarism software
- SHERPA/RoMEO online resource
- JANE, Elsevier Journal Finder, Springer Journal Suggester
- SPPU: Predatory publications software
- Scopus, Web of science, Scimago
- UGC CARE

## O) Suggested Learning Resources:

### a) Books

| S. No. | Titles | Author(s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 1 | Philosophy of Science | Bird, A | Routledge, ISBN 9781857285048 |
| 2 | Research Ethics: A Philosophical Guide to the Responsible Conduct of Research | Gary Comstock | Cambridge University Press, ISBN: 978-1107614924 |
| 3 | The Oxford Handbook of Research Ethics | Ana Smith Iltis | Oxford University Press, ISBN: 978-0190947750 |
| 4 | Ethics in Research with Human Participants | A. M. Jaggar and B. A. Mullen | SAGE Publications, ISBN: 978-0761926537 |
| 5 | Responsible Conduct of Research | Adil E. Shamoo and David B. Resnik | Oxford University Press, ISBN: 978-0199376025 |
| 6 | Ethics in Social Science Research: Becoming Culturally Responsive | Maria K. E. Lahman | SAGE Publications, ISBN: 978-1506328656 |
| 7 | Ethics and Research with Children: A Case-Based Approac | Eric Kodish, Robert M. Nelson | Oxford University Press, ISBN: 978-0190647254 |
| 8 | Research Misconduct Policy in Biomedicine: Beyond the Bad-Apple Approach | Barbara K. Redman | MIT Press, ISBN: 978-0262018865 |
| 9 | Ethics in Qualitative Research | Tina Miller, Maxine Birch, Melanie Mauthner, Julie Jessop | SAGE Publications ISBN: 978-0857028716 |
| 10 | Research and Publication Ethics: An Introduction | Nimit Chowdhary, Sunayana, Monika Prakash | Taylor & Francis, 2024, ISBN: 1040031773, 9781040031773 |
| 11 | Research and Publication Ethics | Santosh Kumar Yadav | Springer International Publishing, ISBN:9783031269714, 3031269713 |

**b) Online Educational Resources:**

1) https://www.youtube.com/watch?v=mtLPd2u4DiA
2) Research Ethics | Ethics in Research
3) https://www.youtube.com/watch?v=3pjilybtP8g
4) What Are RESEARCH ETHICS? The 4 Ethical Considerations Explained Simply (With Examples)
5) https://www.youtube.com/watch?v=EUeQRE5UJpg
6) Quantitative Data Analysis
7) https://www.youtube.com/watch?v=j9A3ceOBihM
8) Qualitative Data Analysis
9) https://www.youtube.com/playlist?list=PLnIj1GYixjfrOhcWQq_ANzLFDniGYZ_-Q
10) Research and Publication Ethics, University of Delhi
11) https://www.youtube.com/playlist?list=PLT0pRmZM15zISG8az1Ik5OTX6_TAKGWTb
12) Research and publication ethics, Hindi
13) https://www.youtube.com/playlist?list=PL7w57XDoO4xzzBpxcRKO7Cp1hbAbx-1IO
14) Research and Publication Ethics (RPE)
15) https://www.youtube.com/playlist?list=PLMDgYE7XMDq7a0OExax9SwgSt1lb2PJ2E
16) Research and Publication Ethics,Ph.D

## P) Course Curriculum Development Team:

| S. No. | Name and Designation | E-mail Address |
|---|---|---|
| 1. | Dr. Bashirulla Shaik | bshaik@nitttrbpl.ac.in |
| 2. | Dr. Roli Pradhan | rpradhan@nitttrbpl.ac.in |
| 3. | Dr. K Manickavasagam | kmanikavasagam@nitttrbpl.ac.in |

| | |
|---|---|
| **A)** | **Course Title: Research Seminar** |
| **B)** | **Course Code:** |
| **C)** | **Pre-requisite Course (s):** Research Methodology |

**D) Rationale:** The Research Seminar course focuses on enhancing students' skills in effectively presenting, analysing, and synthesising research. It provides opportunities for developing research capabilities, communication skills, academic writing, professional presentation, and critical thinking in structured presentation discussions on the current state of knowledge in their field of study.

**E) Course Outcomes (COs):**

| Course Outcomes (COs) | Course Outcome Statements |
|---|---|
| **CO1** | Prepare various research proposals and explore funding opportunities. |

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

| Board of Study | Course Category and Code | Course Titles | Teaching & Learning Scheme (Hours/Week) | | | | | | Assessment Scheme(Marks) | | | | | | Total Marks (TA+TWA+LA) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Theory Component (TC) | | Lab Instruction (LI) | Term Work (TW) | Total Hours/Week (TC+LI+TW) (For 15 Weeks) | Total Credits (C) | Theory Assessment (TA) | | Term work 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) | |
| **CSE** | | **Research Seminar** | | | | **04** | **04** | **02** | | | **50** | | | | **50** |

**G) 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.

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

**I) Suggested Laboratory Experiences: NA**

**J) Suggested Research Based Problems:**

**K) 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:**

| S. No. | Outcome | Activity | Weeks | *Assessment criteria |
|---|---|---|---|---|
| **1.** | • Identify gaps in current literature to thematic areas that require further exploration. | • Conduct a thorough survey of the discipline /subject area and identify a captivating research interest (thematic area) essential for meaningful exploration. | 1 week | 15% |
| **2.** | • Assess the suitability of a selected thematic area for research purposes. | • Presentation on selecting the Broad research area of interest and collective discussion on the thematic area. | 1 week | 15% |
| **3** | • Compare the methodologies, results, and perspectives of the 15 articles.<br>• Synthesise information from the review to propose new research questions. | • Conduct a thorough analysis of at least 15 articles/sources/patents/monographs/case studies/recent advances/emerging technologies in the chosen research theme.<br>• Effectively present the findings from the review across the specific areas. | 2 weeks | 35% |
| **4** | • Develop a comprehensive and persuasive research proposal that addresses all required components. | • Design a Research proposal and explore the funding opportunities. | 2 Week | 35% |

*Assessment will be based on rubrics

**L) Suggested Specification Table for End Semester Theory Assessment (ETA):** NA

**M) Suggested Instructional/ Implementation Strategies:** NA

**N) Major Equipment, Tools and Software for Laboratory and Research Work: NA**

**O) Suggested Learning Resources:**

**a) Books**

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

**P) Course Curriculum Development Team**

| S. No. | Name and Designation | E-mail Address |
|---|---|---|
| 1. | Dr. Bashirulla Shaik | bshaik@nitttrbpl.ac.in |
| 2. | Dr. Roli Pradhan | rpradhan@nitttrbpl.ac.in |
| 3. | Dr. Ramesh Gupta Burela | rgburela@nitttrbpl.ac.in |

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| | | |
|---|---|---|
| **A)** | **Course Title: Curriculum and Assessment** |  |
| **B)** | **Course Code: PhD-CD-01** | |
| **C)** | **Pre- requisite Course (s):** | |



**D)** **Rationale:** Curriculum and Assessment are the cornerstone of an effective education system, working in tandem to shape and measure the learning experience. The curriculum provides a structured framework that outlines the knowledge, skills and competencies students need to acquire, guiding educators in delivering content that is relevant, coherent and aligned with educational goals. It ensures that learning is purposeful, engaging and responsive to local and global contexts. On the other hand, assessment serves as a vital tool for evaluating student progress, providing feedback and identifying areas for improvement in learning. Through various formative, summative, and diagnostic assessments, teachers can monitor the achievement of learning outcomes and tailor instructions to meet individual needs. This also drives academic achievement and supports holistic development, fostering critical thinking, problem-solving and lifelong learning in learners.

**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 |
|---|---|
| CO1 | Apply the key concepts, theoretical foundations and philosophies of curriculum in shaping futuristic educational practices and policies. |
| CO2 | Develop a flexible curriculum according to contemporary needs, educational standards and stakeholder's needs. |
| CO3 | Plan for effective implementation and evaluation of curriculum to meet educational outcomes. |
| CO4 | Assess the effectiveness and relevance of the programme curriculum by applying the different curriculum implementation and evaluation models. |
| CO5 | Assess the learning outcomes by applying the different concepts, characteristics and assessment tools. |
| CO6 | Develop Instructional/Learning resource material by applying the ADDIE and ASSURE models. |

## F) Teaching & Learning and Assessment Scheme:

| Board of Study | Course Category and Code | Course Title | Teaching & Learning Scheme (Hours/Week) | | | | | | Assessment Scheme (Marks) | | | | | | Total Marks (TA+TWA+LA) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Theory Component (TC) | | Lab Instruction (LI) | Term Work (TW) | Total Hours (TC+LI+TW) (For 15 Weeks) | Total Credits (C) | Theory Assessment (TA) | | Term work 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) | |
| **DCDA** | **PhD-CD-01** | **Curriculum and Assessment** | **02** | **-** | **-** | **06** | **08** | **04** | **25** | **50** | **15** | **10** | **-** | **-** | **100** |

**G) 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.

## H) Theory Session Outcomes (TSOs) and Units:

| Major Theory Session Outcomes (TSOs) | Units | Relevant CO Number(s) |
|---|---|---|
| *TSO 1a.* Establish the relationship between knowledge, education, and curriculum.<br>*TSO 1b.* Articulate the role of curriculum in meeting educational and societal needs.<br>*TSO 1c.* Differentiate between various types of knowledge (formal, informal, tacit) and their influence on curriculum design.<br>*TSO 1d.* Distinguish between curriculum and syllabus, understanding their respective purposes and scopes.<br>*TSO 1e.* Identify the key stakeholders in curriculum design & development and its use.<br>*TSO 1f.* Define the characteristics of an effective curriculum document. | **Unit-1.0 Introduction to Curriculum**<br>1.1 Knowledge and Curriculum<br>1.2 Need for the development of a holistic and comprehensive curriculum<br>1.3 Curriculum & syllabus- purposes and scope<br>1.4 Stakeholders of curriculum document,<br>1.5 Characteristics of good Curriculum document, clarity, coherence, flexibility, relevance, and alignment with learning outcomes<br>1.6 Policy directives for curriculum development.<br>1.7 Introduction to Outcome-Based Education (OBE) and Curriculum.<br>1.8 Curriculum & instructions. | **CO1** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant CO Number(s) |
|---|---|---|
| *TSO 1g.* Explore the role of education policy in ensuring curriculum relevance, equity, and alignment with industry needs. | | |
| *TSO 2a.* Outline the key stages & processes in curriculum planning, design and development.<br>*TSO 2b.* Conduct need assessments, including gathering data from stakeholders (students, teachers, industry).<br>*TSO 2c.* Apply the need assessment results to arrive at curriculum design decisions.<br>*TSO 2d.* Explore contemporary approaches to curriculum development.<br>*TSO 2e.* Develop a specific programme structure that aligns with educational goals and learning outcomes.<br>*TSO 2f.* Compare different models/approaches of curriculum development.<br>*TSO 2g.* Apply appropriate models to design curriculum for specific learning environments and needs.<br>*TSO 2h.* Explore emerging trends and innovations in curriculum design, such as outcome-based education, interdisciplinary/multidisciplinary curricula and technology integration etc.<br>*TSO 2i.* Propose innovative curriculum design solutions for real-world educational scenarios.<br>*TSO 2j.* Explore the multifaceted role of teachers as curriculum designers, developers, implementers, and assessors.<br>*TSO 2k.* Examine the key curriculum reforms outlined in India's National Education Policy (NEP) 2020. | **Unit-2.0 Curriculum Design & Development**<br>2.1 Stages of curriculum development-: Curriculum planning & design<br>2.2 Need assessment for curriculum design and development from different stakeholders. Design of tools for need assessment.<br>2.3 Programme Structure Development – Scheme of studies and scheme of assessment.<br>2.4 Models/ Approaches of Curriculum Development: Tyler and Taba Model.<br>2.5 Innovations in curriculum design & development<br>2.6 Flexible curriculum – Integration of emerging areas/technology in programme structure development.<br>2.7 Curriculum reforms in the context of NEP 2020.<br>2.8 Role of teachers in curriculum design and development.<br>2.9 Elements/ Components of whole programme curriculum document.<br>2.10 Elements/Components of course curriculum document.<br>2.11 Domains of learning and course outcomes. Formulating course outcomes.<br>2.12 Curriculum reforms in implementation of students learning. | **CO2** |
| *TSO 3a.* Enumerate the roles of different stakeholders in effective curriculum implementation.<br>*TSO 3b.* Evolve strategies for effective curriculum implementation. | **Unit-3.0 Curriculum Implementations & Evaluation**<br>3.1 Effective Curriculum Implementation: Issues and Challenges. | **CO3, CO4** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant CO Number(s) |
|---|---|---|
| *TSO 3c.* Address issues and challenges faced during the effective implementation of the curriculum.<br>*TSO 3d.* Analyze critical factors that influence the success or failure of curriculum implementation.<br>*TSO 3e.* Apply the CIPP model to review and evaluate the curriculum.<br>*TSO 3f.* Develop an action plan to review and revise the existing curriculum based on evaluation results and emerging trends in education and the world of work. | 3.2 Role of different stakeholders in effective curriculum implementation.<br>3.3 Factors influencing curriculum implementations, institutional support, teacher's competence, student engagement, entry-level KSA, etc.<br>3.4 Curriculum evaluation –strategies for effective implementation of the curriculum.<br>3.5 CIPP model of curriculum evaluation.<br>3.6 Review and revision of curriculum.<br>3.7 Role of teachers in effective curriculum implementation & evaluation considering the four pillars of NEP 2020- Access, Equity, Quality and Accountability. | |
| *TSO 4a.* Explain the role of assessment in the educational process.<br>*TSO 4b.* Differentiate between assessment, measurement and evaluation.<br>*TSO 4c.* Evaluate various assessment purposes, including diagnosis, feedback, and progress monitoring.<br>*TSO 4d.* Differentiate between "Assessment for Learning", "Assessment of Learning" and "Assessment as Learning" and Assessment before Learning.<br>*TSO 4e.* Differentiate between key characteristics of assessment.<br>*TSO 4f.* Enumerate the importance of outcome-based assessment.<br>*TSO 4g.* Analyze the advantages and limitations of CRT and NRT in different educational settings.<br>*TSO 4h.* Apply appropriate assessment tools and techniques to evaluate course outcomes across different learning domains.<br>*TSO 4i.* Design practical pre-assessment tools to inform curriculum planning and instructional strategies.<br>*TSO 4j.* Explore the envisions of NEP 2020 for advocating holistic, competency-based, and flexible assessment systems. | **Unit-4.0 Leaners Assessment**<br>4.1 Assessment in Education: Importance and Purpose of Assessment.<br>4.2 Basic concept of assessment, measurement and evaluation<br>4.3 Characteristics of assessment validity: reliability, objectivity and practicability.<br>4.4 Basic concepts of assessment: Assessment for learning, Assessment of knowledge, Assessment as learning, Assessment before learning, process and product assessment. Issues and challenges in above assessments.<br>4.5 Outcome-based assessment<br>4.6 Criterion Reference Testing (CRT) and Norms Reference Testing (NRT).<br>4.7 Assessing course outcomes in different domains of learning.<br>4.8 NEP 2020 envisions and assessment reforms. | **CO4**<br>**CO5** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant CO Number(s) |
|---|---|---|
| *TSO 5a.* Assess learning outcome in cognitive, affective, and psychomotor domain for their application in educational assessment.<br>*TSO 5b.* Design assessment tools tailored to evaluate student performance in each domain.<br>*TSO 5c.* Design specification tables that ensure coverage of learning outcomes across different cognitive levels.<br>*TSO 5d.* Design different types of questions (e.g., multiple-choice, short-answer, essay, problem-solving).<br>*TSO 5e.* Design rubrics for evaluating student's performance in different area.<br>*TSO 5f.* Design self-assessment and peer-assessment activities to promote student reflection and ownership of learning. | **Unit -5.0 Tools of Assessment**<br>5.1 Assessment of outcomes in cognitive, affective, and psychomotor domains.<br>5.2 Design of Specification table.<br>5.3 Different types of questions-Multiple choice questions, short answer question, structured essay questions, etc.<br>5.4 Bloom's taxonomy and design of question paper,<br>5.5 Direct and indirect tools of assessment.<br>5.6 Rubrics based assessment: design of rubric for assessing project work, industrial training, seminar, laboratory experiences, workshop experiences, etc.<br>5.7 Student evaluation- Scoring criteria and grading system.<br>5.8 Self-assessment and portfolio-based assessment. | **CO5** |
| *TSO 6a.* Elaborate on the need for instructional material development to enhance teaching and learning processes.<br>*TSO 6b.* Identify various instructional materials and their respective roles in supporting learning outcomes.<br>*TSO 6c.* Apply the conceptual framework to guide the development or selection of instructional resources that align with curriculum objectives and student needs.<br>*TSO 6d.* Apply principled frameworks for developing Instructional/Learning resources.<br>*TSO 6e.* Evaluate the quality and effectiveness of instructional materials. | **Unit-6.0 Learning Resource/Instructional Materials Development Framework**<br>6.1 Need, roles & types of Learning/Instructional Materials (e.g., textbooks, digital resources, hands-on materials).<br>6.2 Conceptual framework for Learning/ Instructional materials development.<br>6.3 Principled frameworks for Learning/Instructional material development: ADDIE and ASSURE | **CO6** |

## I) Suggested Laboratory Experiences: NA

## J) Suggested Research Based Problems

i. Carry out the TNA to develop a diploma, UG and PG program curriculum.
ii. Analyze the TNA data of a program to draw the conclusions
iii. Develop flexible programme structure of Diploma/Degree programme, as per NEP 2020 envisions.

iv. Develop ICT-enabled T-L and assessment tools for effective implementation of the curriculum.

v. Prepare a comparative chart of guidelines of Diploma engineering, UG engineering and PG engineering curriculum development guidelines.

vi. Explore the norms of project, internship, and industrial training in AICTE and UGC guidelines and compare them.

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

**a. Assignment(s):**

Prepare questionnaires and tools to assess the needs of various stakeholders (teachers, students and industry personnel).

**b. Seminar Topics:**

- Emerging models and approaches to curriculum development
- Curriculum for Web-based learning programmes
- NEP envision and curriculum and Assessment Reforms.

**L) 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 Titles | Marks |
|---|---|---|
| CO1 | Unit 1.0 Introduction to Curriculum | 05 |
| CO2 | Unit 2.0 Curriculum Design & Development | 10 |
| CO3 | Unit 3.0 Curriculum Implementations & Evaluation | 09 |
| CO4 | Unit 4.0 Leaner's Assessment | 06 |
| CO5 | Unit 5.0 Tools of Assessment | 12 |
| CO6 | Unit 6.0 Learning Resource/Instructional Materials Development Framework | 08 |
| **Total** | | **50** |

**M) 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.

**N) Major Equipment, Tools and Software for Laboratory and Research Work:** NA

**O) Suggested Learning Resources:**

**a) Books**

| S. No. | Titles | Author(s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 1. | Principles of Curriculum Construction | Balasara, M | Kanishka; First Edition (1 January 2017)<br>ISBN-10: 8173916217,<br>ISBN-13: 978-8173916212 |

| S. No. | Titles | Author(s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 2. | Curriculum Studies: A Model for SAARC countries | Biswas, N. B | Indian Publishers Distributor (1 April 2009), ISBN-10: 8173410798 ISBN-13: 978-8173410796 |
| 3. | Curriculum: Foundations, Principles & Theories | Ornstein, A.C | Pearson; 7th edition (6 January 2016) ISBN-10: 0134060350 ISBN-13: 978-0134060354 |
| 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. | Concept-based Curriculum and Instruction | Erickson, H.L. | Publisher: Corwin; 1st edition (1 August 2006), ISBN-10: 141291700X ISBN-13: 978-1412917001 |
| 6. | 'Curriculum theory and practice' | Smith, M. K. (1996, 2000) | www.infed.org/biblio/b-curric.htm. |
| 7. | The Encyclopedia of Informal Education, | W.F. Pinar | (2004. New York, NY: Peter Lang Publishing, Inc. |

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

**P) Course Curriculum Development Team**

| S. No. | Name and Designation | E-mail Address |
|---|---|---|
| 1. | Dr. J.P. Tegar (Coordinator) | jptegar@nitttrbpl.ac.in |
| 2. | Dr. Anju Rawlley (Co-coordinator) | arawlley@nitttrbpl.ac.in |

| | | |
|---|---|---|
| **A)** | **Course Title: Educational Media Development and Studies** |   |
| **B)** | **Course Code:** MRDE01<br>Paper-II Course Elective: 4 credits | |
| **C)** | **Pre-requisite Course (s):** | |

**D)** **Rationale:** This course offers PhD scholars an in-depth exploration of educational media's creation, implementation, and analysis. It equips scholars with the skills to design innovative media content that enhances learning and engagement in diverse educational settings. The course emphasizes the application of theoretical frameworks in practical media development, ensuring that scholars can produce high-quality educational materials. By understanding current trends and technologies in media, scholars are prepared to lead advancements in educational practices. Additionally, the course fosters critical thinking about media's ethical implications and effectiveness in education, enabling scholars to conduct meaningful research and contribute to policy development. Ultimately, this course prepares scholars to be leaders in the evolving landscape of educational media research, driving improvements in teaching and learning through the thoughtful application of media tools and strategies.

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

| Course Outcomes (COs) | Course Outcome Statements |
|---|---|
| MRDE01.CO1 | Apply communication theories and processes in educational contexts. |
| MRDE01.CO2 | Produce educational media content based on content analysis. |
| MRDE01.CO3 | Use ICT and new educational media technologies in modern learning environments. |
| MRDE01.CO4 | Apply relevant methodology to carry out research in educational media. |
| MRDE01.CO5 | Adapt ethical practices and standards in creating and distributing educational media. |

## F) Teaching & Learning and Assessment Scheme:

| Board of Study | Course Category and Code | Course Titles | Teaching & Learning Scheme (Hours/Week) | | | | | | Assessment Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Theory Component (TC) | | Lab Instruction (LI) | Term Work (TW) | Total Hours (TC+LI+TW) (For 15 Weeks) | Total Credits (C) | Theory Assessment (TA) | | Term work 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) | |
| MRDE | PCC and MRDE01 | Educational Media Development and Studies | 4 | - | - | 4 | 8 | 04 | 15 | 50 | 20 | 15 | - | - | 100 |

**G) Course Curriculum Detailing:** To attain course outcomes, the students are expected to perform/ undergo various activities through classroom, term/ work, self- learning/ field sessions.

## H) Theory Session Outcomes (TSOs) and Units:

| Major Theory Session Outcomes (TSOs) | Units | Relevant CO Number(s) |
|---|---|---|
| *TSO 1a.* Compare Linear, Interactive, and Transactional models in educational contexts based on the research.<br>*TSO 1b.* Apply constructivist principles to design interactive media-based educational content that facilitates learner-centered knowledge construction.<br>*TSO 1c.* Apply social learning theory to design media interventions that leverage observational learning strategies.<br>*TSO 1d.* Design educational media that strategically manage the cognitive load to optimize learner comprehension and retention.<br>*TSO 1e.* Select relevant media to achieve the desired learning outcome.<br>*TSO 1f.* Develop media that systematically enhance learner motivation and engagement.<br>*TSO 1g.* Design media-based learning experiences that promote critical thinking. | **Unit-1.0 Communication Theories and Models- A Research-Based Approach**<br>1.1 **Fundamental Communication Models**: Linear, Interactive, and Transactional models in educational contexts, Barriers to effective communication, Research in Communication models<br>1.2 **Constructivist Theory in Media**: Exploring the Learner-Centered Approach to Educational Content.<br>1.3 **Social Learning Theory**: The role of observational learning and media as educational tools.<br>1.4 **Cognitive Load Theory**: Understanding how media design impacts learning and retention.<br>1.5 **Media Richness Theory**: Selection of relevant media based on learning outcomes.<br>1.6 **Engagement and Motivation Models**: Media's role in learner motivation.<br>1.7 **Critical Pedagogy**: Media as a tool for fostering critical thinking. | **CO1** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant CO Number(s) |
|---|---|---|
| *TSO 1h.* Analyze emerging communication technologies and their potential for transforming educational networked environments. | 1.8 **New Communication Theories**: Examining online and networked educational environments. | |
| *TSO 2a.* Construct educational media with appropriate licensing and open resource strategies.<br>*TSO 2b.* Design comprehensive educational media projects with effective planning and resource management.<br>*TSO 2c.* Apply instructional design models systematically to develop structured educational content.<br>*TSO 2d.* Create learner-centered media content through systematic scripting and storyboarding processes.<br>*TSO 2e.* Produce engaging and pedagogically effective educational video content.<br>*TSO 2f.* Design interactive multimedia learning tools that facilitate engagement and knowledge construction.<br>*TSO 2g.* Apply AI tools in media design and production. | **Unit-2.0 Educational Media Management and Production**<br>2.1 **Overview of Educational Media**- Purpose, types, Licenses, OERs.<br>2.2 **Educational Media Project Management**: Planning, budgeting, and executing media projects.<br>2.3 **Instructional Design Models**: ADDIE, SAM, and others for structured educational content.<br>2.4 **Media Content Development**: Scripting, storyboarding, and designing learner-centred content, Learning outcomes<br>2.5 **Educational Video Production Process**: Creating engaging and informative video content, visual and video editing.<br>2.6 **Interactive Media Production**: Designing multimedia and interactive tools for learning.<br>**2.7 AI in media design and production** | **CO2** |
| *TSO 3a.* Apply blended and hybrid learning models to foster learning.<br>*TSO 3b.* Use various LMS and online learning platforms.<br>*TSO 3c.* Apply Strategies and approaches for collaborative learning experiences.<br>*TSO 3d.* Use relevant apps and extensions in the teaching-learning process.<br>*TSO 3e.* Apply gamification strategies to enhance learner engagement.<br>*TSO 3f.* Use social media platforms for educational purposes.<br>*TSO 3g.* Apply data analytics for monitoring and interpreting learning patterns.<br>*TSO 3h.* Use emerging technologies in an educational context. | **Unit-3.0 ICT-based Learning and New Educational Media**<br>3.1 **Blended and Hybrid Learning Models**: Integrating face-to-face and digital learning, MOOCs<br>3.2 **LMS and Online Learning Platforms**: Moodle, Blackboard, Google Classroom.<br>3.3 **Content Personalization and Adaptive Learning Technologies**.<br>3.4 **Collaborative Learning**: Strategies and approaches for collaborative learning experiences.<br>3.5 **Apps and Extensions for Education**: Use of various apps and extensions for education.<br>3.6 **Gamification in Education**: Enhancing engagement through gamified elements.<br>3.7 **Social Media and Data Analytics**: Using social platforms for various applications, Monitoring and interpreting learning patterns and data<br>3.8 **Emerging Media Technology**: Emerging technologies in education, including VR and AR. | **CO3** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant CO Number(s) |
|---|---|---|
| *TSO 4a.* Use ethical practices in creating educational resources.<br>*TSO 4b.* Use learner's data, maintaining privacy and security.<br>*TSO 4c.* Use resources following intellectual property rights and CC Licenses.<br>*TSO 4d.* Apply strategies to facilitate inclusive access for all learners.<br>*TSO 4e.* Adopt ethics in using AI and Adaptive Learning Technologies.<br>*TSO 4f.* Ensure transparency and accountability in media production.<br>*TSO 4g.* Manage consent and learner privacy in educational data analytics.<br>*TSO 4h.* Ensure compliance with educational media standards. | **Unit-4.0 Educational Media Ethics**<br>4.1. **Ethics in Content Creation**: Accuracy, integrity, and cultural sensitivity, plagiarism.<br>4.2. **Privacy and Data Protection**: Ethical handling of learner data.<br>4.3. **Intellectual Property**: Copyrights, fair use, and open educational resources.<br>4.4. **Accessibility Standards**: Ensuring inclusive access for all learners.<br>4.5. **Ethics in AI and Adaptive Learning Technologies**: Balancing innovation with responsibility.<br>4.6. **Transparency and Accountability in Media Production**.<br>4.7. **Ethical Issues in Educational Data Analytics**: Managing consent and learner privacy.<br>**4.8. Regulatory Standards and Policies**: Compliance with educational media standards. | **CO4** |
| *TSO 5a.* Compare Research Methodologies applicable in Educational Media research.<br>*TSO 5b.* Conduct audience analysis based on the given criteria.<br>*TSO 5c.* Apply relevant techniques for analyzing data in digital learning environments.<br>*TSO 5d.* Measure the effectiveness of educational media on learning outcomes.<br>*TSO 5e.* Evaluate the impact of educational media on learner performance and knowledge acquisition.<br>*TSO 5f.* Analyze themes, patterns, and messages in educational media.<br>*TSO 5g.* Design experiment to measure educational media effectiveness.<br>*TSO 5h.* Utilize surveys, interviews, and focus groups for audience feedback and evaluation. | **Unit-5.0 Educational Media Evaluation and Research**<br>5.1. **Research Methodologies in Educational Media**: Qualitative, quantitative, and mixed-methods research, Online and offline, mixed research, Apps and tools for research<br>5.2. **Audience Analysis:** Demographic analysis, Psychographic analysis, Situational analysis.<br>5.3. **Learning Analytics**: Techniques for analyzing data in digital learning environments.<br>5.4. **Evaluation of Content Impact**: Measuring the effectiveness of educational media on learning outcomes.<br>5.5. **Content Analysis**: Examining educational media themes, patterns, and messages.<br>5.6. **Experimental Design**: Designing experiments to measure educational media effectiveness.<br>5.7. **Audience Feedback and Evaluation Techniques**: Surveys, interviews, and focus groups. | **CO5** |

**I) Suggested Laboratory Experiences:** NA

**J) Suggested Research Based Problems**

**K) Suggested Term Work (TW): Suggested Progressive Theory Assessment (PTA): 15 Marks**

**a. Assignment(s)/ Seminar(s):**
Questions/ Problems/ Exercises/ Tasks to be provided by the course teacher in line with the targeted COs.

**Suggested Term Work (TW): (**Progressive Term Work Assessment-PTWA, 20 Marks)

**b. Micro Projects:** (First Compulsory and anyone from the remaining)

1. Develop relevant media on the selected topic (e-content, Video, PPT, Animation) based on the content analysis, considering the financial and human resources required.
2. Formulate a research proposal for evaluating the effectiveness of media/ evaluation of educational media/ comparative study of educational media.
3. Create a proposal for a MOOC on the emerging area
4. Prepare one Augmented Reality application on the selected topic.
5. Develop a multimedia learning resource for a selected topic.
6. Write an article on ethical issues in media and their solutions.
7. Identify the abilities and competencies of engineering/ higher education teachers with respect to their job roles and application of educational media in the teaching-learning process.

**c. Seminar Topics:** (End-Term Work Assessment- ETWA- 15 Marks)
Will be provided by the course teachers.

**L) 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 |
|---|---|---|
| MRDE01.CO1 | Unit 1.0 Communication Theories and Models- A Research-Based Approach | 6 |
| MRDE01.CO2 | Unit 2.0 Educational Media Management and Production | 12 |
| MRDE01.CO3 | Unit 3.0 ICT and New Educational Media | 12 |
| MRDE01.CO4 | Unit 4.0 Educational Media Ethics | 10 |
| MRDE01.CO5 | Unit 5.0 Educational Media Evaluation and Research | 10 |
| **Total** | | **50** |

**M) 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 lectures, tutorials, case methods, industrial visits, field trips, portfolio-based learning, live demonstrations in classrooms, 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.

## N) Major Equipment, Tools and Software for Term Work and Research Work:

| S. No. | Name of Equipment, Tools and Software | Broad Specifications |
|---|---|---|
| 1. | Computer system | Processor Intel Core i5/ i7, 8 GB RAM, 500 GB SSD, Graphic card |
| 2. | Graphics editing/ video editing/ sound editing software | Adobe Creative Cloud bundle, Open source software |
| 3. | 2D/ 3D Animation software | Animate/ Blender |
| 4. | Video production setup | Media studio, videography, photography equipment |
| 5. | Unity Software | For Augmented Reality application development |

## O) 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 Mayer | Cambridge University Press, Publication date: February 2022, ISBN: 9781108814669 DOI: https://doi.org/10.1017/CBO9781139547369 |
| 2. | Theories and Models of Communication | Paul Cobley and Peter J. Schulz | De Gruyter Mouton Publication, May 2013 ISBN-13978-3110294804 |
| 3. | Cognitive Load Theory | John Sweller, Paul Ayres, and Slava Kalyuga | Springer, 2011, ISBN 978-1-4419-8125-7 e-ISBN 978-1-4419-8126-4, DOI 10.1007/978-1-4419-8126-4 |
| 4. | Mastering AR Development with Unity | Indika Wijesooriya | BPB |
| 5. | 3D Game Development with Unity | Franz Lanzinger | CRC Press |
| 6. | AR with Unity; AR Foundation - A Practical Guide | Jonathan Linowes | Packt Pub. Ltd. |
| 7. | Learning C Sharp with Unity 3D | Alex Okipa | CRC Press |
| 8. | Unity 2020 VR Projects | Jonathan Linowes | Packt Pub. Ltd. |
| 9. | Blender 3D Basics | Gordon Fisher | Packt Pub. Ltd. |
| 10. | Realising 3D Animation in Blender | Sam Brubaker | Packt Pub. Ltd. |

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

1) https://discovery1.delnet.in
2) https://openedx.org
3) https://nmeict.ac.in (National Mission on Education through ICT)
4) http://swayam.gov.in/ (Study Webs of Active-learning for Young Aspiring Minds)
5) https://online-degree.swayam2.ac.in/
6) http://nptel.ac.in/ (National Programme on Technology Enhanced Learning)
7) http://www.vlab.co.in/ (Virtual Labs)
8) http://spoken-tutorial.org (Spoken Tutorial)
9) http://fossee.in (Free and Open Source Software for Education)
10) https://ess.inflibnet.ac.in (e-Shodh Sindhu- Higher Education Electronic Resources)
11) https://pds.inflibnet.ac.in (Shodh Shuddhi- Web-Based Plagiarism detection software)
12) http://cec.nic.in/ (Consortium for Educational Communication)
13) https://www.fullerton.edu/openfullerton/of_find/merlot.php (Multimedia Educational Resource for Learning and Online Teaching- MERLOT)
14) https://ocw.mit.edu (MIT Open Courseware)
15) https://ocw.uci.edu/courses (University of California - Irvine: Open Course Ware)
16) https://www.langcen.cam.ac.uk/opencourseware/opencourseware-index.html (University of Cambridge - Language Centre)
17) https://www.oercommons.org
18) https://openstax.org (free and flexible textbooks and resources)
19) https://www.openculture.com/free_textbooks (200 Free Textbooks: A Meta Collection)
20) https://www.openculture.com/freeonlinecourses (1,700 Free Online Courses from Top Universities)

**P) Course Curriculum Development Team**

| S. No. | Name and Designation | E-mail Address |
|---|---|---|
| 1. | Dr. Sandip S. Kedar (Coordinator) | sskedar@nitttrbpl.ac.in |
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| 4. | Prof. Chanchal Mehra | cmehra@nitttrbpl.ac.in |

| | | |
|---|---|---|
| A) | **Course Title: Technical & Vocational Education Studies** | |
| B) | **Course Code:** TVER-01<br>Course Elective: 4 credits | |
| C) | **Pre-requisite Course (s):** | |

**D) Rationale:** Technical Vocational Education and Training (TVET) plays a vital role in preparing individuals for skilled occupations per industrial and various sector requirements and contributes to the socio-economic development of nations. This comprehensive course provides essential theoretical knowledge on the education system, technical education, New Education Policy 2020, emphasis on the teaching-learning process, curriculum, commercialization of higher education programmes, inculcation of ethics and value systems, vocational education, quality systems, skill requirements and their development strategies, policies for skill development, improving skill assessment using relevant ICT enabled tools. It also provides the basis for holistic development in learners, problem-solving, life-long learning, etc. It also ensures that scholars can carry out high-quality research in the field of TVET.

**E) Course Outcomes (COs):** After completing the course, the following are the industry-expected course outcomes for PhD scholars to accomplish.

| Course Outcomes (COs) | Course Outcome Statements |
|---|---|
| TVES01.CO1 | Adopt national education policies and other government initiatives to develop research proposals in the relevant field. |
| TVES01.CO2 | Prepare a practical plan to evaluate Internship /Apprenticeship / Entrepreneurship using ICT-enabled technology. |
| TVES01.CO3 | Use appropriate skill development models to prepare a competent workforce per IR 4.0 to meet industrial demand. |
| TVES01.CO4 | Apply relevant methodology to develop a programme for conducting research in TVET. |
| TVES01.CO5 | Adopt national standards and ethical practices to formulate quality assurance mechanisms related to TVET. |

## F) Teaching & Learning and Assessment Scheme:

| Board of Studies | Course Category and Code | Course Title | Teaching & Learning Scheme (Hours/Week) | | | | | | Assessment Scheme (Marks) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Theory Component (TC) | | Lab Instruction (LI) | Term Work (TW) | Total Hours (TC+LI+TW) (For 15 Weeks) | Total Credits (C) | Theory Assessment (TA) | | Term work 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) | |
| DTVER | TVER-01 | Technical & Vocational Education Studies | 04 | - | - | 04 | 08 | 4 | 15 | 50 | 25 | 10 | - | - | 100 |

**G) Course Curriculum Detailing:** To attain course outcomes, the students are expected to perform/ undergo various activities through classroom, term/ work, self- learning/ field sessions.

## H) Theory Session Outcomes (TSOs) and Units:

| Ma Major Theory Session Outcomes (TSOs) | Units | Relevant CO Number(s) |
|---|---|---|
| *TSO 1a.* Compare the traditional education system with the current education system.<br>*TSO 1b.* Explore the relevance of various education policies in India in light of TVET.<br>*TSO 1c.* Explain the merits of OBE and its alignment with industry needs.<br>*TSO 1d.* Apply the NSQF and NCrF policies in the given situation.<br>*TSO 1e.* Articulate the role of the National Higher Education Qualification Framework in vocational educational institutes.<br>*TSO 1f.* Analyse the governance policy and explore the areas for improvement. | **UNIT 1: Introduction to the Education System and Policies**<br>**1.1 Education System in India**<br>a. Historical developments in Indian Education Systems<br>b. Scope, philosophies, features and policy directives of various education policies of India<br>c. National Education Policy(NEP)-2020<br>d. Implications of these policies on Technical & Vocational Education.<br>**1.2 Outcome-Based Education**<br>a. Philosophy, key features and implementation strategies<br>**1.3 Scope, salient features and procedure of Policies:**<br>a. National Curriculum Framework for Teachers Education(2009)<br>b. National Skills Qualifications Framework (NSQF) | **CO1,CO4** |

| Ma Major Theory Session Outcomes (TSOs) | Units | Relevant CO Number(s) |
|---|---|---|
| | c. National Credit Framework (NCrF) 2023<br>d. National Higher Education Qualification Framework (NHEQF)<br>1.4 **Governance policies:**<br>a. Policy and Governance in Vocational Education,<br>b. Status and issues of TVET in India<br>c. Analysis of existing policy, issues& challenges and ways to address challenges. | |
| TSO 2a. Elaborate on the significance of TVET priorities at international and national levels in developing a skilled workforce.<br>TSO 2b. Explain the relevance of internships, apprenticeships, and work-based learning to enhance skills per academic and industrial needs.<br>TSO 2c. Establish the relationship between knowledge, education, and curriculum.<br>TSO 2d. Explore the importance of pedagogical approaches in TVET<br>TSO 2e. Propose innovative instructional methods(s) for TVET based on an interdisciplinary/multidisciplinary curriculum using ICT-enabled technology. | **UNIT 2: Overview of Technical Vocational Education& Training (TVET)**<br>2.1 Introduction to Technical and Vocational Education<br>2.2 Historical Development of TVET<br>2.3 Priorities of TVET at the international & National level<br>2.4 TVET Management Industry – Academia and Communication<br>2.5 Internship, Apprenticeship, Work-based Learning and Entrepreneurship<br>2.6 Industry- institute Linkages and Entrepreneurship Development<br>2.7 Pedagogical Approaches in TVET<br>2.8 Instructional Methods: Demonstration, Simulation, Project-Based Learning, Problem-Based Learning | **CO1,CO3** |
| *TSO 3a.* Explain the current and emerging trends in skill development.<br>*TSO 3b.* Compare skill development models<br>*TSO 3c.* Analyse various job descriptions /profiles of the identified industry/organisation and map them with the workforce demands as per IR 4.0<br>*TSO 3d.* Elaborate Issues & Challenges of NPSDE- 2015<br>*TSO 3e.* Design Skill Development Programme and its Implementation&Assessment Strategy<br>*TSO 3f.* Analyse any three-skill development programmes of the | **UNIT 3: Transforming Skill Development**<br>3.1 Introduction to Skill Development, Current Trends and Emerging Trends<br>3.2 Models of Skill Development and Good Practices<br>3.3 Overview of Skill Development Programs and VariousInitiatives<br>3.4 National Skill Development Corporation (NSDC) in India<br>3.5 Sector Skill Council (SSC)<br>3.6 Various job descriptions& profiles and relevant modelsand approaches for skill development<br>3.7 Skill Gaps and Workforce Demands according to IR 4.0<br>3.8 National Policy Skills Development & Entrepreneurship (NPSDE) 2015<br>3.9 Future Skills for the 21st Century | **CO2,CO3** |

| | | |
|---|---|---|
| Union/State Government with their effectiveness and suggest measures for further improvement. | | |
| *TSO 4a.* Apply the need assessment results to arrive at vocational curriculum development.<br>*TSO 4b.* Design the identified/desired curriculum following the intended program goals and learning outcomes.<br>*TSO 4c.* Develop relevant self-learning material for any course of the programme's designed curriculum identified under TSO4b, including appropriate assessment schemes based on learning outcomes.<br>*TSO 4d.* Analyse the factors influencing the implementation of skill development. | **UNIT 4: Planning and Designing of TVET Programmes**<br>4.1. Technical and Vocational Programme – Need Assessment and Analysis<br>4.2. Training Models and Strategic Planning<br>4.3. Learning outcomes and their characteristics<br>4.4. Curriculum Design & Development<br>4.5. Content Design and Instructional Resource Development<br>4.6. Digital Tools and E-Learning Material in Vocational Training<br>4.7. TVET Program Implementation and Skills Assessment Methods<br>4.8. Academic Bank of Credits (ABC) | **CO1,CO4** |
| *TSO 5a.* Explain quality assurance in TVET using relevant examples.<br>*TSO 5b.* Develop a quality assurance plan for a TVET program incorporating various quality control tools for industry.<br>*TSO 5c.* Design and implement assessment tools for NAAC, NBA and QCI to measure learner competence.<br>*TSO 5d.* Conduct a mapping exercise to ensure alignment with NAAC/NBA<br>*TSO 5e.* Analyse the identified TVET program and suggest ways to improve the identified system in sync with recent industry trends. | **UNIT-5: Quality Assurance in TVET**<br>*5.1* Overview of Quality Control<br>*5.2* Quality Assurance Tools & Techniques<br>*5.3* Quality Assurance in TVET Functionsand Initiatives<br>*5.4* Global Trends and Innovations in TVET<br>*5.5* Organisation structure, functions and process of the following:<br>a. Quality Council of India (QCI)<br>b. National Assessment Accreditation Council (NAAC)<br>c. National Board of Accreditation (NBA)<br>d. Accreditation Board for Engineering and Technology (ABET) | **CO2,CO3, CO5** |

**I) Suggested Laboratory Experiences:** NA

**J) Suggested Research Based Problems**

- Investigate successful TVET programs in different countries, analysing their methodologies, outcomes, and impact on the workforce.
- Develop innovative models for integrating TVET into higher education, focusing on specific industries or regions.

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

**a. Assignment(s):**

i. Conduct a comparative analysis of vocational education policies in India and another country of your choice.
ii. Write a report on the current status and challenges of Technical and Vocational Education and Training (TVET) in India.
iii. Develop a policy brief addressing the key issues and challenges in the current vocational education system and propose solutions.

**b. Seminar Topics:**

i. Innovative Models for Integrating TVET into Higher Education
ii. Examine successful case studies and best practices from around the world.
iii. Discussing the emerging role of partnerships between educational institutions and industries.
iv. Analyse the existing policies and propose improvements for better learning outcomes.
v. Examining the impact of emerging technologies on vocational education and training.
vi. Study the barriers and potential solutions for effective TVET implementation in developing regions.
vii. Exploring the role of TVET in promoting sustainable development and green skills.
Study the future trends in the labour market and the role of TVET in preparing the workforce

**c. Learning Activities:**

i. Select a skill development program the National Skill Development Corporation (NSDC) implemented and evaluate its effectiveness. Make recommendations for improvements.
ii. Conduct a field visit to a local vocational or skills training centre or industry and prepare a report focusing on their skill development practices and outcomes.
iii. Organize and facilitate a group discussion on the challenges and opportunities in skill development within the context of Industry 4.0.
iv. Create a presentation on future skills required for the 21st-century workforce based on emerging technologies and industry demands.

**L) 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 |
|---|---|---|---|
| TVES01.CO1 | UNIT 1 | Introduction to the Education System and Policies | 10 |
| TVES01.CO2 | UNIT 2 | Overview of Technical Vocational Education & Training (TVET) | 10 |
| TVES01.CO3 | UNIT 3 | Transforming Skill Development | 12 |
| TVES01.CO4 | UNIT 4 | Planning and Designing of TVET Programmes | 10 |
| TVES01.CO5 | UNIT-5 | Quality Assurance in TVET | 08 |
| | | **Total** | **50** |

**M) 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.

The suggested instructional strategies may include the 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.

**N) Major Equipment, Tools and Software for Laboratory and Research Work: NA**

**O) Suggested Learning Resources:**

**a) Books**

| S. No. | Titles | Author(s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 1. | Technical and Vocational Education and Training: Issues, Concerns and Prospects | Rupert Maclean | 1st Edition, Springer, 2022 |
| 2. | Technical and Vocational Education and Training | Jian-Hong Ye and Man Jiang | 1st Edition, IntechOpen, 2024<br>ISBN: 978-1-4020-8346-4 |
| 3. | Information and Communication Technology in Technical and Vocational Education and Training for Sustainable and Equal Opportunity | Reem Khamis, Hamdan Allam Hamdan, BahaaeddinAlareeni, Rim El Khoury | 1st Edition, Springer, 2024<br>ISBN: 978-1-83769-011-4 |
| 4. | Curriculum Studies: A Model for SAARC countries | Biswas, N. B | Indian Publishers Distributor (1 April 2009), ISBN-10: 8173410798<br>ISBN-13: 978-8173410796 |
| 5. | Curriculum: Foundations, Principles & Theories | Ornstein, A.C | Pearson; 7th edition (6 January 2016)<br>ISBN-10: 0134060350<br>ISBN-13: 978-0134060354 |
| 6. | Concept-based Curriculum and Instruction | Erickson, H.L. | Publisher: Corwin; 1st edition (1 August 2006), ISBN-10:141291700X<br>ISBN-13: 978-1412917001 |
| 7. | Curriculum theory and practice | Smith, M. K. (1996, 2000) | www.infed.org/biblio/b-curric.htm. |
| 8. | The Encyclopedia of Informal Education | W.F. Pinar | (2004. New York, NY: Peter Lang Publishing, Inc. |
| 9. | Craft Shaping Society: Educating in the Crafts—The Global Experience | Lindy Joubert | 1st Edition, Springer, 2022<br>ISBN: 978-981-99-7797-0 |
| 10. | The Value of TVET in Advancing Human Development and Reducing Inequalities: The Case of Palestine | RandaHilal | 1st Edition, Springer, 2022<br>ISBN: 978-981-16-9472-1 |

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

- Historical developments in Indian Education Systems: https://educationforallinindia.com/the-present-status-of-indias-education-system-a-critical-analysis-2024/
- Scope, philosophies, features and policy directives of various education policies of India: https://sleepyclasses.com/indian-education-system-reforms/
- National Education Policy (NEP)-2020: (https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English.pdf
- Implications of these policies on Technical & Vocational Education: https://ijcrt.org/papers/IJCRT2205082.pdf
- Philosophy, key features and implementation strategies: https://www.eklavya.com/blogs/procedures-in-implementing-outcome-based-education
- National Curriculum Framework for Teachers Education (2009): https://ncte.gov.in/Website/PDF/NCFTE_2009.pdf
- National Skills Qualifications Framework (NSQF): https://nqr.gov.in/nsqf
- National Credit Framework (NCrF) 2023: https://www.ugc.gov.in/pdfnews/9028476_Report-of-National-Credit-Framework.pdf
- National Higher Education Qualification Framework (NHEQF): https://www.ugc.gov.in/KeyInitiative?ID=CjV3jqYIZhtroLHLDug2Ew
- Policy and Governance in Vocational Education: https://journals.sagepub.com/doi/pdf/10.2304/rcie.2010.5.3.224
- Status and issues of TVET in India: https://ijcrt.org/papers/IJCRT2404026.pdf
- Analysis of existing policy, issues & challenges and ways to address challenges: https://skillsip.nsdcindia.org/sites/default/files/kps-document/TVET%20Landscape%20and%20Stakeholders_February2020_0.pdf
- https://openstax.org (free and flexible textbooks and resources)
- https://www.openculture.com/free_textbooks (200 Free Textbooks: A Meta Collection)
- https://www.openculture.com/freeonlinecourses (1,700 Free Online Courses from Top Universities)
- http://fossee.in (Free and Open Source Software for Education)
- https://ess.inflibnet.ac.in (e-Shodh Sindhu- Higher Education Electronic Resources)
- https://pds.inflibnet.ac.in (ShodhShuddhi- Web-Based Plagiarism detection software)
- http://cec.nic.in/ (Consortium for Educational Communication)

**P) Course Curriculum Development Team**

| S. No. | Name and Designation | E-mail Address |
|---|---|---|
| 1. | Dr. Ajay K. Sarathe (Coordinator), Professor DMEE & Head DTVER | aksarathe@nitttrbpl.ac.in |
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| 6. | Dr. Ranjit Singh, Associate Professor | ranjitsingh@nitttrbpl.ac.in |

| | | |
|---|---|---|
| **A)** | **Course Title: Finite Element Analysis** | Deemed to be University under Distinct Category |
| **B)** | **Course Code: PhD-CE-01** | |
| **C)** | **Pre- requisite Course(s): Strength of Materials** | |

**D)** **Rationale:** Finite Element Method (FEM) is a very popular numerical technique to analyse a wide range of structures across various disciplines ranging from civil, mechanical, aerospace, to biomechanics, etc. This method is a highly versatile tool especially for problems that consisting of generalized geometry, materials, loading and boundary conditions. In this course fundamental concepts underlying the FEM are explained in detail. A general frame work of FEM procedure at element level and assembly level will be taught. Gauss Quadrature numerical schemes are used for the evaluation stiffness matrices and force vector. A detailed step by step analysis will be demonstrated for various types of elements. Algorithms and flowcharts will be used to explain FE program development using Matlab/python. Hands on sessions are conducted on commercial FEA software to illustrate various analyses.

**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 |
|---|---|
| CO1 | Apply the Rayleigh-Ritz method to solve the various continuum structural problems. |
| CO2 | Apply finite element analysis to solve various 3-D linear elastic static problems. |
| CO3 | Formulate element stiffness matrices for various problems. |
| CO4 | Evaluate numerical schemes for the solution of various systems of equations. |
| CO5 | Predict the behavior of 1D and 2D structural systems involving various bars, beams, and plates. |
| CO6 | Perform structural and thermal analyses of various practical engineering problems. |

## F) Teaching & Learning and Assessment Scheme:

| Board of Study | Course Category and Code | Course Titles | Teaching & Learning Scheme (Hours/Week) | | | | | | Assessment Scheme (Marks) | | | | | | Total Marks (TA+TWA+LA) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Theory Component (TC) | | Lab Instruction (LI) | Term Work (TW) | Total Hours/Week (TC+LI+TW) (For 15 Weeks) | Total Credits (C) | Theory Assessment(TA) | | Term work 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 | |
| **DCEEE** | **PhD-CE-01** | **Finite Element Analysis** | **04** | **-** | **02** | **02** | **08** | **04** | **10** | **50** | **10** | **10** | **10** | **10** | **100** |

**G) 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.

## H) Theory Session Outcomes (TSOs) and Units:

| Major Theory Session Outcomes (TSOs) | Units | Relevant CO Number(s) |
|---|---|---|
| *TSO 1a.* Identify the geometry, material properties, loads, and boundary conditions in a given structural problem.<br>*TSO 1b.* Explain the relationship between thermal, structural, and electrical analogies in 1D systems.<br>*TSO 1c.* Explain the significance of the kinematic, constitutive, and equilibrium equations in structural analysis.<br>*TSO 1d.* Differentiate between plane stress, plane strain, and axisymmetric cases.<br>*TSO 1e.* Use the principle of minimum potential energy to find the equilibrium configuration of the given simple structure.<br>*TSO 1f.* Explain the role of virtual work in solving structural problems. | **Unit-1.0 Mathematical Models and Approximations**<br>1.1 Basic ingredients of structural analysis (geometry, material, loads, and boundary conditions)<br>1.2 Thermal-structural-electrical analysis 1D analogy<br>1.3 Governing equations for structural analysis (kinematics, constitutive law, equilibrium equations)<br>1.4 Governing equations for 2D cases: Plane stress, Plane strain, and axisymmetric<br>1.5 Principle of minimum potential energy<br>1.6 Rayleigh-Ritz method<br>1.7 Principle of virtual work.<br>1.8 Philosophy of solving continuum problems using the Finite Element Method. | **CO1** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant CO Number(s) |
|---|---|---|
| *TSO 1g.* Apply key principles to solve the given continuum problems using the Finite Element Method (FEM). | | |
| *TSO 2a.* Explain the procedure of finite element formulation for the given 3-D linear elastic static problem.<br>*TSO 2b.* Use shape functions to derive displacement approximations for simple elements in the given finite element model.<br>*TSO 2c.* Explain the role of each component (stiffness matrix, load vector, displacement vector) in the finite element analysis process.<br>*TSO 2d.* Apply the principles of shape functions, stiffness matrix, and boundary conditions to the given finite element model to find a solution. | **Unit-2.0 Linear finite element procedures in solid mechanics**<br>2.1 Finite element formulation for 3-D linear elastic statics<br>2.2 Shape functions or interpolation functions.<br>2.3 Stiffness matrix, load vector, and displacement vector formulation.<br>2.4 Properties of the stiffness matrix<br>2.5 Application of different types of boundary conditions to a system of equations | **CO2** |
| *TSO 3a.* Compute shape functions for the elements in 1D, 2D, and 3D domains.<br>*TSO 3b.* Apply graphical representations of shape functions and explore refinement techniques (h-refinement and p-refinement).<br>*TSO 3c.* Derive 1D shape functions for the given finite element problems.<br>*TSO 3d.* Plot shape functions for the given 1D, 2D, and 3D elements.<br>*TSO 3e.* Implement h and p-refinement strategies in the given finite element problems.<br>*TSO 3f.* Explain the mapping process in finite element analysis.<br>*TSO 3g.* Formulate element stiffness matrices using 1D, 2D, and 3D mapped elements. | **Unit-3.0 Computation of element matrices and vectors**<br>3.1 Shape or Interpolation function for rectangular and triangular elements in 2D<br>3.2 Shape or Interpolation function for hexahedral and tetrahedral elements in 3D.<br>3.3 Shape or Interpolation function for 1D elements<br>3.4 Graphical representation of shape functions.<br>3.5 h-refinement and p-refinement<br>3.6 Mapping of elements: geometry and displacement fields<br>3.7 Element stiffness using mapped elements: 1D, 2D and 3D | **CO3, CO4** |
| *TSO 4a.* Explain the numerical integration schemes and Gauss quadrature process for the given 1D, 2D, and 3D elements.<br>*TSO 4b.* Apply the Gauss elimination method to solve linear systems of equations efficiently. | **Unit-4.0 Numerical schemes**<br>4.1 Numerical integration schemes.<br>4.2 Gauss Quadrature: Gauss points and weights for 1D, 2D and 3D elements<br>4.3 Gauss elimination method for solving a linear system of equations<br>4.4 Sparse matrix and storage schemes | **CO4** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant CO Number(s) |
|---|---|---|
| *TSO 4c.* Implement sparse matrix storage schemes for a given finite element problem. | | |
| *TSO 5a.* Develop finite element formulations for the given structural members, such as bars/beams/ and plates.<br>*TSO 5b.* Explain each step in the assembly process of the given finite element model.<br>*TSO 5c.* Implement a numbering scheme for the given simple finite element model. | **Unit -5.0 Finite Element Analysis of Structural Members**<br>5.1 Finite element formulation of bar<br>5.2 Finite element formulation of beam<br>5.3 Finite Element Formulation of Plate<br>5.4 Assembly process.<br>5.5 Numbering scheme | **CO5** |
| *TSO 6a.* Solve Poisson's equation using the Finite Element Method.<br>*TSO 6b.* Apply FEM to solve Laplace's equation for steady-state field problems.<br>*TSO 6c.* Analyze linear steady-state heat conduction problems using FEM. | **Unit-6.0 Finite Element Analysis of Steady State Field Problems**<br>6.1 Solution of Poisson's equation and Laplace equation using FEM<br>6.2 Linear steady state heat conduct problem | **CO6** |

## I) Suggested Laboratory Experiences:

| Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment Titles | Relevant COs Number (s) |
|---|---|---|---|
| *LSO 1.1.* Draw Bending moment and shear force diagrams, and identify the point of contra flexure for various loading and boundary conditions. | 1. | Calculate bending moments and shear forces in 1D Beam Analysis. | **CO1** |
| *LSO 2.1.* Evaluate displacements, strains, and stresses in a given structural member. | 2. | Find displacement, strain, and stresses in a one-dimensional bar/beam under axial/transverse loading using a Virtual lab. | **CO2 & CO5** |
| *LSO 3.1.* Analysis of various element types for a given structural element/members | 3 | Compare the performance of finite elements (1D beam, 2D plate, etc.) subjected to various loading and boundary conditions. | **CO3 & CO4** |
| *LSO 4.1.* Evaluate displacements, strains, and stresses for a given plate problems | 4 | Analyse a rectangular plate under plane stress or plane strain conditions. | **CO5** |
| *LSO 5.1.* Analyze products for a given loading conditions | 5. | Perform static analysis to study the behavior of products under mechanical and thermal loads. | **CO2 & CO6** |

**J) Suggested Research-Based Problems**

i. Multi-physics analysis of soft-gripper.
ii. Analysis of green composites
iii. Generative AI
iv.

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

**a. Assignment(s):**

- Derive 3D governing equations in cylindrical coordinate system
- Derive the 3D constitutive law for isotropic material
- Derive shape functions for 2D element
- Draw the shape functions for four noded rectangular element
- Derive Gauss quadrature sampling points and weights for triangular element

**b. Seminar Topics:**

- Analysis and design of Metamaterials
- AI & ML and FEA
- Topology optimization

**L) 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 Mathematical Models and Approximations | 8 |
| CO2 | Unit 2.0 Linear finite element procedures in solid mechanics | 8 |
| CO3 | Unit 3.0 Computation of element matrices and vectors | 10 |
| CO4 | Unit 4.0 Numerical schemes | 8 |
| CO5 | Unit 5.0 Finite Element Analysis of Structural Members | 9 |
| CO6 | Unit 6.0 Finite Element Analysis of Steady State Field Problems | 7 |
| **Total** | | **50** |

**M) 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.

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

**a)** Matlab
**b)** Siemens NX
**c)** Desktop/Laptop

## O) Suggested Learning Resources:

### a) Books

| S. No. | Titles | Author(s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 1. | Finite Element Analysis | C.S. Krishnamoorthy | Publisher: McGraw Hill Education<br>Edition: 2, 2017,<br>ISBN: 9780074622100 |
| 2. | The Finite Element Method in Engineering | S.S. Rao | Publisher: Elsevier<br>Edition: 6, 2019<br>ISBN: 935107384X |
| 3. | The Finite Element Method using MATLAB | Young W. Known | Publisher: CRC Press<br>Edition: 2, 2007<br>ISBN: 978-0495084969 |

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

1) Basics of Finite Element Analysis-I, IIT Kanpur
https://nptel.ac.in/courses/112104193
2) Finite Element Analysis, IIT Kharagpur
https://nptel.ac.in/courses/105105041
3) Finite Element Method: Variational Methods to Computer Programming, IIT Guwahati
https://nptel.ac.in/courses/112103295
4) Finite Element Method for Vibration and Stability Analyses, IISc Bangalore
https://nptel.ac.in/courses/105108141

## P) Course Curriculum Development Team

| S. No. | Name and Designation | E-mail Address |
|---|---|---|
| 1. | Dr. Ramesh Gupta Burela (Coordinator) | rgburela@nitttrbpl.ac.in |

| | | |
|---|---|---|
| **A)** | **Course Title:** Artificial Intelligence & Machine Learning | , |
| **B)** | **Course Code: PhD-CS-01** | |
| **C)** | **Pre-Requisite Course(s):** Python Programming | |

**D)** **Rationale:** Artificial intelligence (AI) is a superset of learning techniques such as Machine Learning (ML), Reinforcement learning (RL) and Deep learning (DL). Generally, AI can enhance learning capacity and enrich the decision-making process for various emerging applications, including medical, security, and business. The machine uses AI to learn enormous volumes of data through ML, RL, and DL algorithms. This course covers the types of AI, agents, searching techniques, knowledge representation, understanding natural languages, and the role of AI in decision-making and learning processes. These components help create effective real-time applications.

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

| Course Outcomes (COs) | Course Outcome Statements |
|---|---|
| CO1 | Apply informed search techniques for different applications. |
| CO2 | Use knowledge representation techniques for resolving the problems. |
| CO3 | Identify a suitable learning paradigm in the context of machine learning for given application. |
| CO4 | Apply the machine learning algorithms for making decisions over the given input dataset. |
| CO5 | Validate the classification result through statistical analysis |

## F) Teaching & Learning and Assessment Scheme:

| Board of Study | Course Category and Code | Course Titles | Teaching & Learning Scheme (Hours/Week) | | | | | | Assessment Scheme (Marks) | | | | | | Total Marks (TA+TWA+LA) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Theory Component (TC) | | Lab Instruction (LI) | Term Work/Self Learning (TW/SL) | Total Hours/Week (TC+LI+TW/SL) (For 15 Weeks) | Total Credits | Theory Assessment (TA) | | Term work 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) | |
| **Computer Science & Engg. (CSE)** | **PhD-CS-01** | **Artificial Intelligence & Machine Learning** | **02** | **01** | **03** | **02** | **08** | **04** | **10** | **50** | **10** | **-** | **15** | **15** | **100** |

**G) 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.

## H) Theory Session Outcomes (TSOs) and Units:

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| *TSO 1a.* Differentiate the types of AI and intelligent agents.<br>*TSO 1b.* Apply a suitable search algorithm to resolve the problems.<br>*TSO 1c.* Resolve the constraint satisfaction problem.<br>*TSO 1d.* Perform the means end analysis for the solutions<br>*TSO 1e.* Apply a suitable shortest path algorithm to reduce the search time.<br>*TSO 1f.* Use propositional logic to solve any simple problems<br>*TSO 1g.* Use first order predicate logic to resolve complex problems | **Unit-1.0 Searching Techniques in AI**<br>1.1 Introduction to artificial intelligence, Types of AI and intelligent agents.<br>1.2 Breadth-first search, depth-first search, hill climbing and its variations<br>1.3 Heuristics search techniques: best-first search, A* algorithm,<br>1.4 Constraint satisfaction problem<br>1.5 Means-end analysis<br>1.6 Introduction to game playing, min-max and alpha-beta pruning algorithms.<br>1.7 Introduction to knowledge Representation | **CO1** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| | 1.8 Propositional logic<br>1.9 First-Order logic<br>1.10 Predicate logic | |
| *TSO 2a.* Find the relative score between formal language and natural language towards grammatically.<br>*TSO 2b.* Calculate the quality scores of the languages through relative scores.<br>*TSO 2c.* Categorize the formal languages based on expressiveness and complexity.<br>*TSO 2d.* Analyse the sentences of documents<br>*TSO 2e.* Find the user preferences by using utility theory.<br>*TSO 2f.* Design a decision network for any products with respect to the user requirements.<br>*TSO 2g.* Create and resolve any sequential decision problems.<br>*TSO 2h.* Find the solutions to gaming problems. | **Unit-2.0 Natural Languages**<br>2.1 Components and steps of communication<br>2.2 The contrast between formal and natural languages in the context of grammar<br>2.3 Chomsky hierarchy of grammars, parsing, and semantics<br>2.4 Parsing Techniques<br>2.5 Context-Free and Transformational Grammars<br>2.6 Recursive and Augmented transition nets.<br>2.7 Utility theory and functions<br>2.8 Decision networks<br>2.9 Sequential decision problems and<br>2.10 Game Theory | **CO2** |
| *TSO 3a.* Explain the Machine Learning techniques.<br>*TSO 3b.* Identify the suitable learning paradigm for given machine learning problems.<br>*TSO 3c.* Explain the learning process of machine learning algorithms in sequence.<br>*TSO 3d.* Explain the roles of machine learning in AI applications.<br>*TSO 3e.* Identify the suitable ML algorithms for the given AI applications.<br>*TSO 3f.* Explain the Chi-Square and T-test Analysis with examples.<br>*TSO 3g.* Apply the basics mathematics for resolving problems through ML | **UNIT 3.0: BASICS OF MACHINE LEARNING**<br>3.1 Introduction to Machine Learning<br>3.2 Learning paradigms: Supervised, Unsupervised and Semi-supervised<br>3.3 PAC Learning<br>3.4 Version Spaces<br>3.5 Role of Machine Learning in Artificial Intelligence applications<br>3.6 Statistical Analysis: Chi-Square & T-Test<br>3.7 Basic Mathematics for Machine Learning: Probability & Matrix | **CO3** |
| *TSO 4a.* Differentiate the linear and non-linear through examples.<br>*TSO 4b.* Resolve the problems using Naïve Bayes, multiclass and multi-label classifiers.<br>*TSO 4c.* Use the suitable regression algorithm to resolve the problems<br>*TSO 4d.* Apply suitable decision tree algorithms to resolve the problems. | **UNIT 4.0: SUPERVISED LEARNING**<br>4.1 Linear and Non-Linear examples<br>4.2 Multiclass and Multi-label classification<br>4.3 Linear regression and Multiple Linear Regression<br>4.4 Naive Bayes classifier<br>4.5 Decision Trees - ID3 – CART<br>4.6 k-NN classifier | **CO4 & CO5** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| *TSO 4e.* Use the k-NN classifier and logistic regression to resolve the problems.<br>*TSO 4f.* Differentiate the single and multi-layer Perceptron.<br>*TSO 4g.* Use the suitable Perceptron to find the solution for the problems.<br>*TSO 4h.* Differentiate the Linear and non-linear SVM.<br>*TSO 4i.* Use the suitable Perceptron to find the solution for the problems<br>*TSO 4j.* Evaluate the classifiers by conducting experiments with respect to the standard evaluation metrics.<br>*TSO 4k.* Correct the errors while applying the classifiers. | 4.7 Logistic regression<br>4.8 Perceptron (single layer and multi-layer)<br>4.9 Support Vector Machines (Linear & Non-Linear)<br>4.10 Evaluation Metrics & Error Correction | |
| *TSO 5a.* Use suitable clustering techniques for grouping the data in the problem-solving process.<br>*TSO 5b.* Differentiate the available clustering algorithms<br>*TSO 5c.* Apply the classifiers to resolve the problems.<br>*TSO 5d.* Enhance the performance of the classifiers using optimization techniques.<br>*TSO 5e.* Evaluate the clustering and classifiers by conducting experiments with respect to the standard evaluation metrics.<br>*TSO 5f.* Correct the errors while applying the classifiers.<br>*TSO 5g.* Combine the prediction results of the classifiers using Bagging and boosting methods.<br>*TSO 5h.* Enhance the performance of the ensemble classifier using Bagging and boosting methods in the process of problem solving.<br>*TSO 5i.* Evaluate the ensemble learning model by conducting experiments with suitable evaluation metrics.<br>*TSO 5j.* Correct the errors while applying the ensemble classifier.<br>*TSO 5k.* Explain the RL with the framework<br>*TSO 5l.* Use a mathematical framework for modeling the decision-making problems | **UNIT 5.0: Unsupervised & Reinforcement Learning**<br>5.1 Clustering basics (Partitioned, Hierarchical and Density based)<br>5.2 K-means clustering and K-Mode clustering<br>5.3 Self-Organizing Maps<br>5.4 Expectation maximization<br>5.5 Principal Component Analysis and Kernel PCA<br>5.6 tSNE (t-distributed stochastic neighbour embedding)<br>5.7 Metrics & Error correction<br>5.8 Bagging and Boosting (Random Forests, Ada-boost, XG Boost inclusive)<br>5.9 Basics of RL and RL framework<br>5.10 Markov Decision Process<br>5.11 Exploration Vs Exploitation<br>5.12 Value Functions and Bellman equations- solution methods - Q-learning | **CO4 & CO5** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| [where the results are not stable]<br>*TSO 5m.* Differentiate exploration and exploitation.<br>*TSO 5n.* Predict the future states in the prediction process of RL. | | |

**I) Suggested Laboratory Experiences**

| Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment Titles | Relevant COs Number (s) |
|---|---|---|---|
| *LSO 1.1.* Implement the hill climbing, BFS and DFS algorithms.<br>*LSO 1.2.* Measure the performance of the hill climbing, BFS and DFS algorithms. | 1. | Write a Python code to implement the below search algorithms<br>i) Hill climbing search algorithm.<br>ii) BFS algorithm.<br>iii) DFS algorithm. | **CO1 & CO2** |
| *LSO 2.1.* Implement the A*, AO* and Min-Max search algorithms.<br>*LSO 2.2.* Measure the performance of the A*, AO* and Min-Max search algorithms. | 2. | Write a Python code to implement the below search algorithms<br>i) A* search algorithm.<br>ii) AO* search algorithm<br>iii) Min-Max search algorithm. | **CO1 & CO2** |
| *LSO 3.1.* Find the solution for the Water-Jug Problem by considering two jugs with different capacities.<br>*LSO 3.2.* Measure the efficiency of the solution. | 3. | Write a Python code to solve the Water-Jug Problem by considering two jugs with the capacity of 5 and 3 liters. | **CO1 & CO2** |
| *LSO 4.1.* Develop the solution for Sudoku problem using constraint satisfaction by considering the specific size.<br>*LSO 4.2.* Measure the performance of the Sudoku problem solution with respect to the necessary evaluation parameters. | 4. | Implement the sudoku problem (minimum 9×9 size) using constraint satisfaction using Python programming language. | **CO1 & CO2** |
| *LSO 5.1.* Implement knowledge representation using frames with appropriate examples.<br>*LSO 5.2.* Measure the efficiency of the frames on knowledge representation. | 5. | Write a Python code to implement knowledge representation using frames with<br>appropriate examples. | **CO1 & CO2** |
| *LSO 6.1.* Identify the suitable dataset for performing linear and logistic regression. | 6 | Implement the following supervised learning algorithms on small data sets.<br>a. Linear regression<br>b. Logistic regression | **CO3, CO4 &** |

| Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment Titles | Relevant COs Number (s) |
|---|---|---|---|
| *LSO 6.2.* Preprocess the input dataset.<br>*LSO 6.3.* Evaluate the system using appropriate metrics such as means squared error or accuracy. | | | **CO5** |
| LSO 7.1. Implement the suitable dataset for performing linear and logistic regression.<br>LSO 7.2. Preprocess the input dataset.<br>LSO 7.3. Evaluate the system using appropriate metrics such as means squared error or accuracy. | 7 | Implement the following clustering algorithms after performing the pre-processing on synthetic datasets.<br>a. k-means clustering<br>b. k-mode clustering | **CO3, CO4 & CO5** |
| *LSO 8.1.* Preprocess the heart dataset.<br>*LSO 8.2.* Train the heart dataset.<br>*LSO 8.3.* Evaluate the k-NN classifier using the metrics (Accuracy, Precision, Recall, F1-Score, Specificity, Sensitivity and Serendipity)<br>*LSO 8.4.* Perform the time analysis.<br>*LSO 8.5.* Calculate the misclassification rate. | 8 | Apply k-NN classifier for performing training and testing processes on heart disease dataset and evaluate the classifier by considering the evaluation metrics such as Accuracy, Precision, Recall, F1-Score, Specificity, Sensitivity and Serendipity.<br>***Task 1:*** The workflow of the k-NN for your dataset is also to be uploaded<br>***Task 2:*** The following results need to be given:<br>i. Time analysis for training dataset by considering the different number of k values (4 values) and different sizes (20%, 40%, 60%, 80% and 100%)<br>ii. Time analysis for testing dataset (30%) by considering the different number of k values (4 values). | **CO3, CO4 & CO5** |
| LSO 9.1. .Preprocess the KDD'99 cup dataset.<br>LSO 9.2. Train the KDD'99 cup dataset.<br>LSO 9.3. Evaluate the Naïve Bayes classifier using the metrics (Accuracy, Precision, Recall, F1-Score, Specificity, Sensitivity and Serendipity).<br>LSO 9.4. Perform the time analysis.<br>LSO 9.5. Calculate the misclassification rate. | 9 | Apply Naïve Bayes Classifier for performing training and testing processes on share market dataset and evaluate the classifier by considering the evaluation metrics such as Accuracy, Precision, Recall, F1-Score, Specificity, Sensitivity and Serendipity.<br>***Task 1:*** The workflow of the Naïve Bayes classifier for your dataset is also to be uploaded<br>***Task 2:***The following results need to be given:<br>iv) Time analysis for training dataset by considering the different number sizes of (20%, 40%, 60%, 80% and 100%) datasets. | **CO3, CO4 & CO5** |

| Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment Titles | Relevant COs Number (s) |
|---|---|---|---|
| | | v) Time analysis for testing dataset (30%) by considering the different number of record sets.<br>vi) Find the misclassification rate for the training and testing dataset by considering the different sizes of the datasets. | |
| *LSO 10.1.* Implement LSO 5.1: Preprocess the NSL-KDD dataset.<br>*LSO 10.2.* Train the NSL-KDD dataset.<br>*LSO 10.3.* Evaluate the ID3 classifier using the metrics (Accuracy, Precision, Recall, F1-Score, Specificity, Sensitivity and Serendipity).<br>*LSO 10.4.* Perform the time analysis.<br>*LSO 10.5.* Calculate the misclassification rate. | 10 | Apply ID3 Classifier for performing training and testing processes on NSL-KDD dataset and evaluate the classifier by considering the evaluation metrics such as Accuracy, Precision, Recall, F1-Score, Specificity, Sensitivity and Serendipity.<br><br>***Task 1:*** The workflow of the ID3 classifier for your dataset is also to be uploaded<br>***Task 2:***The following results need to be given:<br>a. Time analysis for training dataset by considering the different number sizes of (20%, 40%, 60%, 80% and 100%) datasets.<br>b. Time analysis for testing dataset (30%) by considering the different number of record sets.<br>c. Find the misclassification rate for the training and testing dataset by considering the different sizes of the datasets. | **CO3, CO4 & CO5** |
| *LSO 11.1.* ImplementLSO 6.1: Preprocess the Arrhythmia disease dataset.<br>*LSO 11.2.* Train the Arrhythmia disease dataset.<br>*LSO 11.3.* Evaluate the CART classifier using the metrics (Accuracy, Precision, Recall, F1-Score, Specificity, Sensitivity and Serendipity).<br>*LSO 11.4.* Perform the time analysis.<br>*LSO 11.5.* Calculate the misclassification rate. | 11 | Apply CART for performing training and testing processes on Arrhythmia disease dataset and evaluate the classifier by considering the evaluation metrics such as Accuracy, Precision, Recall, F1-Score, Specificity, Sensitivity and Serendipity.<br><br>***Task 1:*** The workflow of the CART classifier for your dataset is also to be uploaded<br>***Task 2:*** The following results need to be given:<br>i. Time analysis for training dataset by considering the different number sizes of (20%, 40%, 60%, 80% and 100%) datasets.<br>ii. Time analysis for testing dataset | **CO3, CO4 & CO5** |

| Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment Titles | Relevant COs Number (s) |
|---|---|---|---|
| | | (30%) by considering the different number of record sets.<br>iii. Find the misclassification rate for the training and testing dataset by considering the different sizes of the datasets. | |
| *LSO 12.1.* Preprocess the diabetic disease dataset.<br>*LSO 12.2.* Train the diabetic disease dataset.<br>*LSO 12.3.* Evaluate the MLP classifier using the metrics (Accuracy, Precision, Recall, F1-Score, Specificity, Sensitivity and Serendipity).<br>*LSO 12.4.* Perform the time analysis.<br>*LSO 12.5.* Calculate the misclassification rate. | 12 | Apply MLP for performing training and testing processes diabetic disease dataset and evaluate the classifier by considering the evaluation metrics such as Accuracy, Sensitivity, Specificity, Positive predictive value (PPV), Training and Testing time, R square score, Root Mean Squared Error (RMSE), Mean Absolute Error (MAE)and Median Absolute Error (MdAE).<br><br>***Task 1:*** The workflow of the MLP classifier for your dataset is also to be uploaded<br>***Task 2:*** The following results need to be given:<br>i. Time analysis for training dataset by considering the different number sizes of (20%, 40%, 60%, 80% and 100%) datasets.<br>ii. Time analysis for testing dataset (30%) by considering the different number of record sets.<br>iii. Find the misclassification rate for the training and testing dataset by considering the different sizes of the datasets.<br>iv. Provide the confusion matrix. | **CO3, CO4 & CO5** |
| *LSO 13.1.* Preprocess the cancer dataset.<br>*LSO 13.2.* Train the cancer dataset.<br>*LSO 13.3.* Evaluate the k-means clustering algorithm using the metrics (Accuracy, Precision, Recall, F1-Score, Specificity, Sensitivity and Serendipity).<br>*LSO 13.4.* Perform the time analysis.<br>*LSO 13.5.* Calculate the misclassification rate. | 13 | Apply k-Means clustering algorithm to form clusters for cancer disease dataset. Evaluate the algorithm by using the evaluation metrics such as sum squared errors, k-values (k-number of clusters), time taken for forming each cluster and overall time taken. Moreover, provide the manual workflow for the sample records of your own dataset.<br><br>***Task 1:*** The workflow of the k-Mode clustering for your dataset is also to be uploaded<br>***Task 2:*** The following results need to be | **CO3, CO4 &** |

| Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment Titles | Relevant COs Number (s) |
|---|---|---|---|
| | | given:<br>i. Time analysis for input dataset to form clusters by considering the different number sizes of (50%, 60%, 70%, 80%, 90% and 100%) datasets.<br>ii. Time analysis to form clusters for the entire dataset.<br>iii. Calculate the clustering accuracy.<br>iv. Comparative analysis between K-Means clustering and k-Mode clustering algorithms with respect to time taken and clustering accuracy. | **CO5** |
| *LSO 14.1.* Preprocess the weather dataset.<br>*LSO 14.2.* Train the weather dataset.<br>*LSO 14.3.* Evaluate the k-NN classifier using the metrics (Accuracy, Precision, Recall, F1-Score, Specificity, Sensitivity and Serendipity).<br>*LSO 14.4.* Perform the time analysis.<br>*LSO 14.5.* Calculate the misclassification rate. | 14 | Apply k-Mode clustering algorithm to form clusters for weather dataset. Evaluate the algorithm by using the necessary evaluation metrics including precision, recall, f-measure, accuracy, time taken for forming each cluster and overall time taken.<br>***Task 1:*** The workflow of the k-Mode clustering for weather dataset is also to be uploaded<br>***Task 2:*** The following results need to be given:<br>i. Time analysis for input dataset to form clusters by considering the different number sizes of (50%, 60%, 70%, 80%, 90% and 100%) datasets.<br>ii. Time analysis to form clusters for the entire dataset.<br>iii. Calculate the clustering accuracy.<br>iv. Comparative analysis between K-Means clustering and k-Mode clustering algorithms with respect to time taken and clustering accuracy. | **CO3, CO4 & CO5** |
| *LSO 15.1.* Preprocess the network dataset.<br>*LSO 15.2.* Train the network dataset.<br>*LSO 15.3.* Evaluate the ensemble classifier using the metrics (Accuracy, Precision, Recall, F1-Score, Specificity, Sensitivity and Serendipity).<br>*LSO 15.4.* Perform the time analysis. | 15 | Develop an attack prediction system by incorporating an ensemble classifier using k-NN and ID3. Enhance the performance using a boosting algorithm and prove the same. Consider the necessary metrics including Accuracy, Precision, Recall, F1-Score, Specificity, Sensitivity and Serendipity. | **CO3, CO4 & CO5** |

| Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment Titles | Relevant COs Number (s) |
|---|---|---|---|
| *LSO 15.5.* Calculate the misclassification rate. | | | |
| *LSO 16.1.* Preprocess the disease dataset.<br>*LSO 16.2.* Train the disease dataset.<br>*LSO 16.3.* Evaluate the Q-learning using the metrics (Accuracy, Precision, Recall, F1-Score, Specificity, Sensitivity and Serendipity).<br>*LSO 16.4.* Perform the time analysis.<br>*LSO 16.5.* Calculate the misclassification rate. | 16 | Develop a Disease prediction system by incorporating Q-Learning. Consider the necessary metrics including Accuracy, Precision, Recall, F1-Score, Specificity, Sensitivity and Serendipity. | **CO3, CO4 & CO5** |

**J). Suggested Research Based Problems: NA**

**K). Suggested Term Work (TW) and Self Learning (SL):**

**a. Assignment(s):**

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

1. Develop a new e-healthcare system with the incorporation of a feature selection and optimization method and an ensemble method by using the following classifiers:
   i) Spotted Hyena Optimization Algorithm (SHOA)
   ii) Multi-layer Perceptron (MLP)
   iii) Fuzzy Decision Tree (FDT)

   Here, the SHOA is used to extract the relevant optimal features from the disease dataset. Then, the ensemble method with the combination of MLP and FDT 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.

2. The objective of this research work is to develop a new Intrusion Detection System (IDS) by using a new feature selection algorithm and a classifier. This IDS consists of a newly developed a new Mutual Information based Feature Reduction (MIFR) technique and a hybrid classifier which combines a Weighted K-NN classifier and Random Forest classifier. Here, the MIFR is used to identify the more relevant features and the hybrid classifier is used to predict the attacks such as Probe, DoS, U2R and R2L. The NSL-KDD dataset is sued as input data for conducting experiments and proved as effective by obtaining better prediction accuracy than other IDSs.

**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.**

**b. Seminar Topics:**

- AI in Innovations
- Role of AI & ML in Agriculture
- Role of AI & ML in Education
- Role of AI & ML in Cyber Security
- Role of AI & ML in Industrial 4.0
- Role of AI & ML in Healthcare
- Role of AI & ML in Business
- Role of AI & ML in Environmental Sciences

**L). 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 Searching Techniques in AI | 10 |
| CO2 | Unit 2.0 Natural Languages | 10 |
| CO3 | Unit 3.0 Basics of Machine Learning | 08 |
| CO4 | Unit 4.0 Supervised Learning | 10 |
| CO5 | Unit 5.0 Unsupervised & Reinforcement Learning | 12 |
| Total | | 50 |

**M). 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.

**N). 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 |

## O. Suggested Learning Resources:

### a) Books

| S. No. | Titles | Author(s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 1 | Artificial Intelligence: A Modern Approach | S. Russell and P. Norvig | Prentice Hall, Third Edition, 2015. |
| 2 | Introduction to Artificial Intelligence & Expert Systems | Patterson | Pearson, 1st ed. 2015 |
| 3 | Introduction to Machine Learning | E. Alpaydin. | MIT Press, 2nd edition, 2010 |
| 4 | Reinforcement Learning: An Introduction | R. S. Sutton and A. G. Barto | MIT Press, 1998 |
| 5 | 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 |
| 6 | 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 |

### b) Online Educational Resources:

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. http://www.digimat.in/nptel/courses/video/106104189/L01.html
6. https://onlinecourses.nptel.ac.in/noc19_cs82/preview
7. https://vitalflux.com/machine-learning-nptel-courses-list-2023/
8. Data Source
    - https://www.kaggle.com
    - UNSW dataset
    - UCI Machine Learning Repository

## P. Course Curriculum Development Team

| S. No. | Name and Designation | E-mail Address |
|---|---|---|
| 1. | Dr. Sanjay Agrawal, *Professor* | sagrawal@nitttrbpl.ac.in |
| 2. | Dr. M. A. Rizvi, *Professor* | marizvi@nitttrbpl.ac.in |
| 3. | Dr. R. K. Kapoor, *Professor* | rkkapoor@nitttrbpl.ac.in |
| 4. | Dr. S. Ganapathy, *Associate Professor* | sganapathy@nitttrbpl.ac.in |

| | | |
|---|---|---|
| **A)** | **Course Title: Soft Computing** | |
| **B)** | **Course Code: PhD-EC-01** | |
| **C)** | **Pre- requisite Course (s): Set Theory** | |

**D)** **Rationale:** Soft computing is an alternative methodology based on a Neural Network consortium and Fuzzy Logic. It offers the superiority of humanlike problem-solving in Al-oriented applications where a fast approximate solution to a vaguely formulated problem is the prime concern. The case study of a machine vision problem amply demonstrates the power of soft computing in perceptual tasks. As the knowledge-based approach used by traditional AI approaches saturation. The Course provides perceptual and Al-oriented skills tasks in a heterogeneous distributed environment, while solving numeric intensive tasks

**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 |
|---|---|
| CO1 | Apply fuzzy logic principles to design various intelligent control systems. |
| CO2 | Apply the principles of fuzzy sets and rules to solve various control engineering problems. |
| CO3 | Use neural networks to solve complex industrial problems effectively. |
| CO4 | Develop neural control systems using direct control and T-S fuzzy modelling for various real-world problems. |
| CO5 | Develop hybrid fuzzy-neural control systems for various applications using fuzzy logic, neural networks, and rule generation. |

## F) Teaching & Learning and Assessment Scheme:

| Board of Study | Course Category and Code | Course Titles | Teaching & Learning Scheme (Hours/Week) | | | | | | Assessment Scheme (Marks) | | | | | | Total Marks (TA+TWA+LA) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Theory Component (TC) | | Lab Instruction (LI) | Term Work (TW) | Total Hours (TC+LI+TW) (For 15 Weeks) | Total Credits (C) | Theory Assessment (TA) | | Term work 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) | |
| **Electrical Engineering (EEE)** | **PhD-EC-01** | **Soft Computing** | **03** | **01** | **-** | **08** | **04** | **04** | **25** | **50** | **15** | **10** | **-** | **-** | **100** |

**G) 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.

## H) Theory Session Outcomes (TSOs) and Units:

| Major Theory Session Outcomes (TSOs) | Units | Relevant CO Number(s) |
|---|---|---|
| | **Unit-1.0 Fuzzy Sets and Fuzzy Systems** | **CO1** |
| *TSO 1a.* Explain the concept of Fuzzy Sets and Related concepts with examples.<br>*TSO 1b.* Distinguish between different types of membership functions and their applications.<br>*TSO 1c.* Describe the fuzzy relations and fuzzy logic operations.<br>*TSO 1d.* Solve a reasoning problem using fuzzy reasoning techniques.<br>*TSO 1e.* Design the structure of fuzzy model using the given Mamdani Fuzzy Systems<br>*TSO 1f.* Differentiate between the given Mamdani Fuzzy Systems and Takagi-Sugeno Fuzzy Systems.<br>*TSO 1g.* Apply the given fuzzy logic principle to design an intelligent system. | 1.1 Introduction; Fuzzy Sets and related concepts.<br>1.2 Membership function<br>1.3 Fuzzy Relations and Fuzzy If- then rule<br>1.4 Fuzzy Reasoning Challenges<br>1.5 Fuzzy Model and Fuzzy Systems: Mamdani Fuzzy Systems<br>1.6 Takagi- Sugeno Fuzzy Systems | |
| | **Unit-2.0 Fuzzy Logic Control** | **CO2** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant CO Number(s) |
|---|---|---|
| *TSO 2a.* Explain the roles of each component in a fuzzy logic control system.<br>*TSO 2b.* Evaluate fuzzy rules for a given application.<br>*TSO 2c.* Develop fuzzy models using Mamdani Type fuzzy logic controller.<br>*TSO 2d.* Develop fuzzy models using Takagi-Sugeno Model.<br>*TSO 2e.* Evaluate response time, steady-state error and stability of the fuzzy logic controllers. | **Unit-2.0 Fuzzy Logic Control**<br>2.1 Structure of fuzzy logic control<br>2.2 Generating fuzzy rules<br>2.3 Mamdani Type fuzzy logic controller<br>2.4 Takagi- Sugeno Model Based fuzzy logic control<br>2.5 Time response<br>2.6 Steady state error and stability of the fuzzy logic controller | **CO2** |
| *TSO 3a.* Explain the concept of neural networks with a real-world example.<br>*TSO 3b.* Explain Learning capability and Delta rule.<br>*TSO 3c.* Develop the given neural network model using training and test data.<br>*TSO 3d.* Analyze the computational requirements of the given neural network implementation.<br>*TSO 3e.* Identify common practical issues faced during the training of the given neural networks. | **Unit-3.0 Neural Networks**<br>3.1 Structure of artificial neurons<br>3.2 Learning capability and Delta rule<br>3.3 Training a neural network ,Testing a neural network<br>3.4 Implementing neural networks<br>3.5 Practical issues in training | **CO3** |
| *TSO 4a.* Explain the concept of Neural Control<br>*TSO 4b.* Apply neural control in solving real-time problems.<br>*TSO 4c.* Explain the concept of Inverse dynamics<br>*TSO 4d.* Apply neural network in Temperature Control applications<br>*TSO 4e.* Apply T-S fuzzy models in the given identification problem. | **Unit-4.0 Design of Neural Control**<br>4.1 Neural Control<br>4.2 Requirement of Neural Control<br>4.3 Inverse dynamics<br>4.4 Neural networks in direct neural control Example: Temperature Control<br>4.5 T-S Fuzzy Modelling and Identification | **CO4** |
| *TSO 5a.* Explain the structure of a hybrid fuzzy neural control system.<br>*TSO 5b.* Apply fuzzy concepts in the given simple neural network model.<br>*TSO 5c.* Apply fuzzy-neural principles in the given control problem.<br>*TSO 5d.* Use neural-fuzzy principles to solve the given real-time control problem. | **Unit -5.0 Hybrid Fuzzy-Neural Control**<br>5.1 Structure of Hybrid Fuzzy-Neural Control System<br>5.2 Fuzzy concepts in neural networks<br>5.3 Principles of fuzzy-neural systems<br>5.4 Principles of neural-fuzzy systems<br>5.5 Generating fuzzy rules<br>5.6 Applications of Fuzzy Logic Controller<br>5.7 Applications of Neural Network Control | **CO2, CO3, CO5** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant CO Number(s) |
|---|---|---|
| *TSO 5e.* Apply a fuzzy logic controller in the given system<br>*TSO 5f.* Apply neural network control in the given systes.<br>*TSO 5g.* Apply hybrid fuzzy-neural controller in the given system | 5.8 Applications of Hybrid Fuzzy-Neural Controller | |

**I) Suggested Laboratory Experiences:** NA

**J) Suggested Research-Based Problems**

i. Design a Fuzzy Logic Controller for a chosen application using simulation by performing the following:

- Select a suitable membership function for the Fuzzy Logic Controller
- Justify the following:

1. Number of membership function
2. Type of membership function
3. Type of rule base chosen

ii. Fuzzy controllers are becoming alternatives to classical controllers as they enable engineering expertise. Design a fuzzy and hybrid of fuzzy logic and conventional controller for the chosen system and compare the system's performances with the designed controllers.
In this context, prepare a project proposal to implement “Design fuzzy logic controller and hybrid controller for a chosen application using simulation”. The proposal should address the following:

- Choose a suitable fuzzification and defuzzification method and show its calculation
- Integrate the Fuzzy Controller, a hybrid controller in the chosen system
- Compare and analyze the performance characteristics of the controllers
- Select a better controller based on the performance

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

**a. Assignment(s):**

Prepare questionnaires and tools to assess the needs of various stakeholders (teachers, students and industry personnel).

**b. Seminar Topics:**

- Application of Fuzzy PID Control
- Application of Fuzzy Sliding Mode Control
- Application of Adaptive Fuzzy Control

**L) 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 Fuzzy Sets and Fuzzy Systems | 12 |
| CO2 | Unit 2.0 Introduction to Fuzzy Logic Control | 12 |
| CO3 | Unit 3.0 Introduction to Neural Networks | 10 |
| CO4 | Unit 4.0 Design of Neural Control | 08 |
| CO5 | Unit 5.0 Hybrid Fuzzy-Neural Control | 08 |
| **Total** | | **50** |

**M) 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.

**N) Major Equipment, Tools and Software for Laboratory and Research Work: NA**

**O) Suggested Learning Resources:**

**a) Books**

| S. No. | Titles | Author(s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 1. | Fuzzy System Engineering | Nadia Nedjah, Luiza de Macedo Mourelle | Springer, Year: 2010 ISBN: 9783642064609,3642064604 |
| 2. | Artificial intelligence and soft computing: behavioral and cognitive modeling of the human brain | Amit Konar | CRC Press, Year: 2000 ISBN: 9780849313851, 0849313856 |
| 3. | Principles of Soft Computing | S. N. Sivanandam , S. N. Deepa | Wiley, 3rd edition, 2018 |
| 4. | Soft Computing in Green and Renewable Energy Systems | Kasthurirangan Gopalakrishnan , Siddhartha Kumar Khaitan, Soteris Kalogirou | Springer-Verlag Berlin and Heidelberg GmbH & Co. K, 2016 ISBN: 978-366252000 |

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

**P) Course Curriculum Development Team**

| S. No. | Name and Designation | E-mail Address |
|---|---|---|
| 1. | Dr. K. Manickavasagam, Professor, DEEEE | kmanickavasagam@nitttrbpl.ac.in |

| | | |
|---|---|---|
| A) | **Course Title: Computer Aided Design and Analysis** | |
| B) | **Course Code: PhD-ME-02** | |
| C) | **Pre- requisite Course (s):** | |

**D) Rationale:** This Course provides information for engineers on computerizing their design processes. Most engineering companies use calculations on geometry during design processes. Product visualization and analysis are required in all stages of product development. This course shows how to replace current manual techniques by computer. The course focuses on strengthening the theoretical and practical knowledge of the students in the core areas of design and analysis so as to meet the needs of the industries as well as R&D organizations. Hands on sessions are conducted on commercial CAD software, Programming language. Students will be able to used and analyse Computer Aided Design methods and procedures in product development

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

| Course Outcomes (COs) | Course Outcome Statements |
|---|---|
| CO1 | Identify CAD methods and procedures in various product development. |
| CO2 | Apply algorithms to solve geometric transformation problems and visualise various objects. |
| CO3 | Implement curve and surface representation algorithms for modelling and analysis of various shapes. |
| CO4 | Create various product models using the fundamentals of solid modelling. |
| CO5 | Analyse data exchange formats in the development of various products. |

## F) Teaching & Learning and Assessment Scheme:

| Board of Study | Course Category and Code | Course Titles | Teaching & Learning Scheme (Hours/Week) | | | | | | Assessment Scheme (Marks) | | | | | | Total Marks (TA+TWA+LA) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Theory Component (TC) | | Lab Instruction (LI) | Term Work (TW) | Total Hours/Week (TC+LI+TW) (For 15 Weeks) | Total | Theory Assessment (TA) | | Term work 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) | ve Lab Assessment (PLA) | ratory Assessment (ELA) | |
| | **PhD-ME-02** | **Computer Aided Design and Analysis** | **02** | **01** | **03** | **02** | **08** | **04** | **10** | **50** | **10** | **-** | **15** | **15** | **100** |

**G) 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.

## H) Theory Session Outcomes (TSOs) and Units:

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| *TSO 1a.* Explain the product development stages and lifecycle.<br>*TSO 1b.* Outline the historical developments of CAD.<br>*TSO 1c.* Identify the requirements of CAD in product development.<br>*TSO 1d.* Identify the process parameters in CAD product development.<br>*TSO 1e.* Select appropriate hardware and software for the given situation.<br>*TSO 1f.* Select appropriate software for the situation. | **Unit-1.0 Computer Aided Design and Analysis**<br>1.1 Product life cycle<br>1.2 Historical development of CAD<br>1.3 Role of CAD in the design process<br>1.4 CAD hardware and software<br>1.5 Parametric solid modelling software | CO1 |
| *TSO 2a.* Create objects using boundary points.<br>*TSO 2b.* Implement Transformation and visualisation for the given objects. | **Unit-2.0 Geometric Transformations**<br>2.1 Representation of points;<br>2.2 Transformation of geometric models: translation, scaling, reflection, rotation and sharing | CO2 |

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| *TSO 2c.* Represent given objects and their transformations in a homogeneous coordinate system.<br>*TSO 2d.* Explain the algorithms to the given geometric transformation problems for visualisation.<br>*TSO 2e.* Explain clipping and hidden line removal on objects for a given condition. | 2.3 Homogeneous representation, concatenated transformations,<br>2.4 Inverse transformations,<br>2.5 Clipping-hidden line removal. | |
| *TSO 3a.* Create a parametric representation of the given analytic curves.<br>*TSO 3b.* Analyse parametric representation of the given analytic curves<br>*TSO 3c.* Analyse the parametric representation of synthetic curves.<br>*TSO 3d.* Implement curve represent algorithms for analysis of the given shape. | **Unit-3.0 Plane and Space Curves**<br>3.1 Parametric representation of analytic curves: circle, ellipse<br>3.2 Parametric representation of analytic curves: parabola and hyperbola; Conic sections<br>3.3 Parametric representation of synthetic curves like Cubic splines, Bezier curve, B-spline curve.<br>3.4 Curve Design, Parametric Space of a Curve, Re-parameterization<br>3.5 Rational Polynomials, NURBS. | CO3 |
| *TSO 4a.* Analyse algebraic and geometric forms for the given surfaces.<br>*TSO 4b.* Create the given type of surfaces representation.<br>*TSO 4c.* Implement the synthetic surfaces computationally.<br>*TSO 4d.* Apply Euler operators to validate the given objects.<br>*TSO 4e.* Apply Euler regularised Boolean Operators to create the given objects.<br>*TSO 4f.* Create a boundary representation of a given object.<br>*TSO 4g.* Create a solid model for the given object using the constructive solid geometry approach. | **Unit-4.0 Surfaces and 3D Modeling**<br>4.1 Fundamental of Surface Design, Parametric Space of a Surface<br>4.2 Re-parameterization of a Surface patch, sixteen-point form<br>4.3 Four Curve Form, surfaces of revolution, Sweep surfaces<br>4.4 Quadric surfaces; Bilinear surfaces; Ruled and developable surfaces, Bezier surfaces; B-spline surfaces.<br>4.5 Solid modelling: Topology and Geometry, set theory, Euler Operators,<br>4.6 Regularized Boolean Operators, Boundary Representation, Constructive Solid Geometry. | CO3<br>CO4 |
| *TSO 5a.* Inspect the neutral and native formats used in product development.<br>*TSO 5b.* Apply the direct and indirect translation of the product model across given applications. | **Unit-5.0 Data Exchange Formats**<br>5.1 CAD/CAM data exchange formats. Direct and Indirect translators.<br>5.2 Neutral file formats: Data Exchange Format (DXF), Standard Triangular Languages (STL), | CO5 |

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| *TSO 5c.* Analyse given neutral file formats for product development. | 5.3 Neutral file formats: Initial Graphics Exchange Specification (IGES),<br>5.4 Standard for the Exchange of Product Data (STEP 3D) format. | |

## I) Suggested Laboratory Experiences:

| Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment Titles | Relevant COs Number (s) |
|---|---|---|---|
| *LSO1.1.* Model 2D Geometries.<br>*LSO1.2.* Analyse 2D Drawings | **1.** | Sketching basic and complex geometries using various constraints and dimensions using CAD modelling package. | **CO1** |
| *LSO 2.1.* Model 3D components.<br>*LSO 2.2.* Analyse Part Drawings | **2.** | Modelling 3-dimensional objects using part design workbench using CAD modelling package. | **CO1, CO4** |
| *LSO 3.1.* Model assemblies of product models.<br>*LSO 3.2.* Analyse assemblies of product models. | **3.** | Modelling assemblies of product models containing multiple parts using an Assembly workbench using a CAD modelling package. | **CO1, CO4** |
| *LSO 4.1.* Create production drawings | **4.** | Generating drafting and production drawings using layout workbench and CAD modelling package. | **CO1, CO4** |
| *LSO 5.1.* Write computer program for 2D transformation for simple cases | **5.** | 2D Transformations of objects using a programming language – simple cases. | **CO2** |
| *LSO 6.1.* Write a computer program for 2D transformation with given conditions for complex cases. | **6.** | 2D Transformations of objects with specified conditions using a programming language – complex cases. | **CO2** |
| *LSO 7.1.* Write a computer program for 3D transformation with given conditions | **7.** | 3D Transformations of objects with specified conditions using a programming language. | **CO2** |
| *LSO 8.1.* Write computer program for a given synthetic curve.<br>*LSO 8.2.* Analyse created synthetic curve | **8.** | Generation of synthetic curves for given conditions using a programming language. | **CO3** |
| *LSO 9.1.* Write a computer program for given synthetic surface.<br>*LSO 9.2.* Analyse created synthetic surface | **9.** | Generation of synthetic curves for given conditions using a programming language. | **CO3** |
| *LSO 10.1.* Develop learning portfolio | **10.** | Presentation of student portfolio on the labs performed. | **CO1-CO4** |

## J) Suggested Research Based Problems:

i. Development of an algorithm for generating NURBS surfaces for defining any kind of surface.
ii. Development of algorithm to find curves/points for two intersecting surfaces

iii. Development of an algorithm for generating a B-spline surface for user-defined conditions and analyzing the algebraic and geometric conditions.

## K) 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:**

- Points representation of given solid models.
- Apply a set of given transformations for given solid models.
- Write Bezier / B-spline cure for given points and explain the properties.
- Compare Bezier and B-spline cures.
- Write 16 points form for a given surface.
- Compare STL, STEP, and IGES neutral formats for the product data exchange.

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

| COs | Relevant Unit Number and Title | Marks |
|---|---|---|
| CO1 | Unit-1.0 Introduction to Computer Aided Design and Analysis | 10 |
| CO2 | Unit-2.0 Geometric Transformations | 10 |
| CO3 | Unit-3.0 Plane and Space Curves | 10 |
| CO4 | Unit-4.0 Surfaces and 3D Modeling | 10 |
| CO5 | Unit-5.0 Data Exchange Formats | 10 |
| **Total** | | **50** |

**M) 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.

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

| S. No. | Name of Equipment, Tools and Software | Broad Specifications | Relevant Experience /Practical Number |
|---|---|---|---|
| 1. | Computer system | Processor Intel Core i7, 8 GB RAM, 25 GB free disk space | All |
| 2. | Design and Development tools | SolidWorks, NX CAD, MATLAB | All |

## O) Suggested Learning Resources:

### a. Books

| S. No. | Titles | Author(s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 1. | Mathematical Elements for Computer Graphics | David F. Rogers and J. Alan Adams | Tata McGraw-Hill Edition, ISBN: 978-0070535305 |
| 2. | CAD/CAM: Theory and Practice | Ibrahim Zeid, R Sivasubramanian | Tata McGraw-Hill, ISBN: 978-0070151345 |
| 3. | CAD/CAM Principles and Applications | P.N.Rao | Tata McGraw-Hill, ISBN: 978-0070681934 |
| 4. | Geometric Modeling | Michael E. Mortenson | John Wiley, ISBN: 978-0471129578 |
| 5. | Computer-Aided Engineering Design | Anupam Saxena, Birendra Sahay | Springer, ISBN: 978-1402025556 |

### b. Online Educational Resources:

1) URL: https://nptel.ac.in/courses/112104031
2) URL: https://archive.nptel.ac.in/courses/112/102/112102101/

## P) Course Curriculum Development Team

| S. No. | Name and Designation | E-mail Address |
|---|---|---|
| 1. | Dr. Ravi Kumar Gupta | rkgupta@nitttrbpl.ac.in |

| | |
|---|---|
| **A)** | **Course Title: Digital Manufacturing** |
| **B)** | **Course Code: PhD-ME-03** |
| **C)** | **Pre- requisite Course (s):** |

**D) Rationale:** This course is essential as it comprehensively covers the evolution and modern advancements in manufacturing. It delves into virtual manufacturing and simulation tools, numerical control systems, computer-integrated manufacturing, and flexible manufacturing systems. Additionally, it explores smart manufacturing and Industry 4.0 technologies, highlighting the transformative roles of IoT, AI, and machine learning. This holistic approach ensures that students are prepared to lead and innovate in the rapidly evolving digital manufacturing landscape. The course emphasises strengthening theoretical and practical knowledge by demonstrating how to replace current manual procedures with digital alternatives. This comprehensive approach equips students with the skills needed to meet the demands of modern industries and R&D organisations, preparing them to lead and innovate in digital manufacturing.

**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 |
|---|---|
| CO1 | Analyze the architecture of various digital manufacturing systems. |
| CO2 | Apply various methods and tools in virtual manufacturing to optimize manufacturing processes. |
| CO3 | Implement adaptive control systems to optimize various machining processes. |
| CO4 | Apply various ML techniques for predictive maintenance and quality control. |
| CO5 | Apply Various industry 4.0 technologies for quality assurance and predictive maintenance. |

## F) Teaching &Learning and Assessment Scheme:

| Board of Study (BOS) | Course Code | Course Category | Course Titles | Teaching & Learning Scheme (Hours) | | | | | | Assessment Scheme(Marks) | | | | | | Total Marks(TA+TWA+LA) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Theory Component (TC) | | Lab Component (LC) | Term Work (TW) and Self Learning (SL)(TW+SL) | Total Hours (I+T+LC+TW+SL) | Total Credits (C) | Theory Assessment (TA) | | Term work & Self-Learning Assessment (TWA) | | Lab Assessment (LA) | | |
| | | | | Input (I) | Tutorial (T) | | | | | Progressive Theory Assessment (PTA) | End Term Theory Assessment (ETA) | Progressive Term Work Assessment (PTWA) | End Term Work Assessment (ETWA) | Progressive Lab Assessment | End Term Laboratory Assessment (ELA) | |
| **DMEE** | **PhD-ME-03** | **PCC** | **Digital Manufacturing** | **02** | **01** | **03** | **02** | **08** | **04** | **10** | **50** | **10** | **-** | **15** | **15** | **100** |

**G) Course Curriculum Detailing:** For the attainment of course outcomes, the students are expected to perform/ undergo various activities in the classroom, laboratories/ workshops term/ work, and 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.

## H) Theory Session Outcomes (TSOs) and Units:

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| *TSO1a.* Outline the historical perspective in digital manufacturing system.<br>*TSO1b.* Write in brief the role of the Industrial Revolution in digital manufacturing. System.<br>*TSO1c.* Differentiate between traditional and digital manufacturing systems.<br>*TSO1d.* Analyse the operation mode of given digital manufacturing.<br>*TSO1e.* Analyse the architecture of the digital manufacturing system. | **Unit-1. Digital Manufacturing**<br>1.1 Industrial Revolutions.<br>1.2 Historical perspective on industrial production.<br>1.3 Differences between traditional and digital manufacturing.<br>1.4 Factory of the future.<br>1.5 Operation Mode and Architecture of Digital Manufacturing System. | CO1 |
| *TSO 2a.* Differentiate the given types of virtual manufacturing processes/ products/factories.<br>*TSO 2b.* Identify the sequence of steps in the given virtual manufacturing processes from design to execution.<br>*TSO 2c.* Identify the tools and methods used in virtual manufacturing.<br>*TSO 2d.* Identify the method for the given virtual manufacturing. | **Unit-2. Virtual Manufacturing**<br>2.1 Types of Virtual Manufacturing: Process, Product, Factory simulation<br>2.2 Virtual factory simulation.<br>2.3 Role of simulation in manufacturing<br>2.4 Methods and Tools Used in Virtual Manufacturing | CO2 |

| | | |
|---|---|---|
| *TSO 2e.* Identify the virtual industrial application of virtual manufacturing.<br>*TSO 2f.* Apply appropriate tools and methods in virtual manufacturing for optimisation of the manufacturing process. | 2.5 Virtual Manufacturing Workflow<br>2.6 Applications of Virtual Manufacturing<br>2.7 Challenges and Future Trends | |
| *TSO 3a.* Explain the given NC, CNC, and DNC principles and their application in modern machining.<br>*TSO 3b.* Compare conventional machining techniques with CNC systems, including their advantages and limitations.<br>*TSO 3c.* Implement adaptive control systems to optimize machining processes based on real-time data and conditions.<br>*TSO 3d.* Apply interpolators to generate complex tool paths for the given machining operations. | **Unit-3.0 Numerical Control of Machine Tools**<br>3.1 Principles of Numerical control (NC), Computer Numerical control (CNC), Direct Numerical Control (DNC)<br>3.2 Comparison between conventional and CNC systems<br>3.3 Classification of CNC system, NC coordinate system, positional control, and system devices.<br>3.4 Drives, ball screws, transducers, feedback devices, counting devices, signal converters<br>3.5 Interpolators, adaptive control system | CO3 |
| *TSO 4a.* Outline the given hierarchical computer system.<br>*TSO 4b.* Identify the components of CIM<br>*TSO 4c.* Differentiate between the given flexible manufacturing systems.<br>*TSO 4d.* Explain the system components with respect to application and benefits.<br>*TSO 4e.* Explain the given manufacturing cell/tool management and workplace handling system.<br>*TSO 4f.* Enlist the benefits of given CIM &FMS. | **Unit-4.0 CIM and FMS**<br>4.1 Hierarchical computer system<br>4.2 Concepts and Components of CIM, types of manufacturing systems, and transfer lines.<br>4.3 Flexible Manufacturing System, Types of Flexibility.<br>4.4 FMS Components, Application & Benefits.<br>4.5 The manufacturing cell, tool management and workpiece handling system.<br>4.6 Benefits of CIM &FMS | CO4 |
| *TSO 5a.* Outline the role of the given IoT and cyber physical system.<br>*TSO 5b.* Explain the mechanism of integration of given IoT and Cyber-physical systems for manufacturing.<br>*TSO 5c.* Enlist the benefits of given smart manufacturing techniques.<br>*TSO 5d.* Identify the IoT/data/AI/ML technology in the given industry 4.0.<br>Explain the role of digital twins for the given industrial application. | **Unit 5: Smart Manufacturing and Industry 4.0**<br>5.1 Role of IoT and cyber-physical systems<br>5.2 Benefits of Smart Manufacturing<br>5.3 Industry 4.0 Technologies: Internet of Things (IoT)<br>5.4 Big data and analytics, Artificial Intelligence (AI) and Machine Learning (ML)<br>5.5 Introduction of digital twin | |

**I) Suggested Laboratory Experiences:**

| Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment Titles | Relevant COs Number (s) |
|---|---|---|---|
| *LSO 1.1.* Utilize advanced digital tools for hands-on experience.<br>*LSO 1.2.* Interpret simulation data to optimize manufacturing layouts. | 1. | Design a basic layout for a future factory using digital tools. | **CO1** |
| *LSO 2.1.* Compare key features of traditional and digital manufacturing processes.<br>*LSO 2.2.* Assess the impact of digital manufacturing on efficiency, cost, and product quality versus traditional methods. | 2. | Conduct a comparative analysis of a traditional manufacturing process and a digital manufacturing process. | **CO1** |
| *LSO 3.1.* Develop Simulation Models for Manufacturing Processes.<br>*LSO 3.2.* Optimize Manufacturing Process Parameters Based on Simulation Results | 3. | Simulate a manufacturing process and analyse its performance. | **CO2** |
| *LSO 4.1.* Interpret Simulation Results to Improve Production Efficiency | 4. | Use process/product simulation software to model a production process. | **CO2** |
| *LSO 5.1.* Operate CNC Machine with safety.<br>*LSO 5.2.* Produce quality parts | 5. | Execute a CNC program for an essential machining operation. | **CO3** |
| *LSO 6.1.* Perform diagnostic tests on CNC systems.<br>*LSO 6.2.* Evaluate the performance of positional control and feedback devices. | 6. | Investigate the functioning of positional control and feedback devices in a CNC system. | **CO3** |
| *LSO 7.1.* Configure automated tool changers for optimal performance.<br>*LSO 7.2.* Operate handling systems to improve efficiency and workflow. | 7. | Investigate the tool management system and workpiece handling in a Computer Integrated Manufacturing (CIM) environment. | **CO4** |
| *LSO 8.1.* Implement feedback control systems.<br>*LSO 8.2.* Utilize IoT devices to adjust processes in real-time based on received data. | 8. | Set up IoT devices to monitor and control a manufacturing process. | **CO5** |
| *LSO 9.1.* Integrate the machine learning model for real-time predictions.<br>*LSO 9.2.* Optimize manufacturing processes continuously for improved efficiency. | 9. | Implement a machine learning model to predict manufacturing outcomes. | **CO5** |
| *LSO 10.1.* Analyze the digital twin simulation results.<br>*LSO 10.2.* Implement targeted strategies to enhance manufacturing operations. | 10. | Create a digital twin of a manufacturing system. | **CO5** |

**J) Suggested Research Based Problems:**

- To develop and implement a digital twin model for real-time monitoring and optimization of a smart manufacturing system.
- To develop a predictive maintenance framework using AI and machine learning techniques for smart manufacturing systems.

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.

**K) Suggested Term Work (TW): Suggested Problems/Micro Projects**: Problems/Micro projects may be designed for the attainment of identified COs/combination of COs

**Suggested Term Work (TW) and Self Learning (SL):**

**a) Assignment(s):** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

- IoT-Enabled Smart Manufacturing System: Develop a prototype of a smart manufacturing system incorporating IoT devices.
- Data Analytics in Manufacturing: Analyze a set of manufacturing data using data analytics tools and present the findings.
- Adaptive Control System for CNC Machines**:** Develop and test an adaptive control system for a CNC machine to enhance machining accuracy and efficiency.
- Process Simulation for Optimization: Develop a process simulation model to identify and optimize critical manufacturing parameters for improved productivity.
- Challenges and Trends in Virtual Manufacturing: Research and present a comprehensive report on the current challenges and future trends in virtual manufacturing.
- Tool Management System in CIM: Develop a tool management system for a CIM environment, focusing on tool tracking, inventory management, and automated tool selection.

  Impact of AI on Manufacturing Processes: Conduct a project that explores how AI and machine learning can be applied to enhance various manufacturing processes and decision-making.

**b) Seminar Topics:**

- The Role of Virtual Manufacturing in the Evolution of Industry 4.0.
- Digital Twins in Manufacturing: Real-time Monitoring and Optimization for Smart Factories.
- Exploring the Impact of Digital Measurement Tools on Quality Control in Manufacturing.
- Computer-Aided Design (CAD): Innovations Driving the Future of Product Development.

**c) Self-Learning**:

- Industrial visit
- Any other activity

**L) 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 Digital Manufacturing | 10 |
| CO2 | Unit 2.0 Virtual Manufacturing | 10 |
| CO3 | Unit 3.0 Numerical control of Machine tools | 10 |
| CO4 | Unit 4.0 CIM and FMS | 10 |
| CO5 | Unit 5.0 Smart Manufacturing and Industry 4.0 | 10 |
| **Total** | | **50** |

**M) 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. To ensure learning, micro project, research-based problems etc may be designed and implemented.

**N) Major Equipment, Tools and Software for Laboratory and Research Work**: NA

**O) Suggested Learning Resources:**

**a) Books**

| S. No. | Titles | Author(s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 1 | Introduction to Digital Manufacturing | Richard Bibb, Dominic Eggbeer, Abby Paterson | Springer, year:2020,I$^{st}$ Edition, ISBN: 978-3030185930 |
| 2 | Virtual Manufacturing | Raj S. Sodhi | Springer, year: 2010, I$^{st}$ Edition, ISBN: 978-3642034204 |
| 3 | Industry 4.0: The Industrial Internet of Things | Alasdair Gilchrist | Apress. Year:2016,1$^{st}$ Edition, ISBN: 978-1484220463 |
| 4 | Manufacturing Systems: Theory and Practice | George Chryssolouris | Springer, year: 2006, I$^{st}$ Edition, ISBN: 978-0387284314 |

**b) Online Educational Resources:**

i. https://www.coursera.org/learn/digital-manufacturing-design
ii. https://www.coursera.org/learn/iot
iii. https://openstax.org/
iv. https://www.saylor.org/
v. https://www.futurelearn.com/

**P) Course Curriculum Development Team**

| S. No. | Name and Designation | E-mail Address |
|---|---|---|
| 1. | Dr.L.S.Raju | rajudme@nitttrbpl.ac.im |

| | | |
|---|---|---|
| **A)** | **Course Title: Optimization and Simulation** | *Deemed University- Distinct category* |
| **B)** | **Course Code: PhD-ME-01** | |
| **C)** | **Pre- requisite Course (s):** | |

**D) Rationale:** Optimization techniques are useful finding the optimum solution of a given problem. Optimum solution is a competitive solution in terms of cost or any functional requirement of a system. Hence, solution of any engineering problem is the final solution only when it has gone through a process of optimization, which makes learning of optimization techniques important for any engineering student.

**E) Course Outcomes (Cos)**

| Course Outcomes (COs) | Course Outcome Statements |
|---|---|
| C01 | Formulate various optimum design problems. |
| C02 | Find the optimum solutions to single variable unconstrained optimization problems. |
| C03 | Find the optimum solution for multivariable unconstrained optimization problems |
| C04 | Solve single and multivariable unconstrained optimization problems using various methods and criteria. |
| C05 | Find optimum solutions to various linear programming problems. |

## F) Teaching &Learning and Assessment Scheme:

| Board of Study (BOS) | Course Code | Course Category | Course Titles | Teaching & Learning Scheme (Hours/Week) | | | | | | Assessment Scheme (Marks) | | | | | | Total Marks(TA+TWA+LA) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Theory Component (TC) | | Lab Component (LC) | Term Work (TW) and Self Learning (SL)(TW+SL) | Total Hours/Week (I+T+LC+TW+SL) | Total Credits (C) | Theory Assessment (TA) | | Term work & Self-Learning Assessment (TWA) | | Lab Assessment (LA) | | |
| | | | | Input (I) | Tutorial (T) | | | | | Progressive Theory Assessment (PTA) | End Term Theory Assessment (ETA) | Progressive Term Work Assessment (PTWA) | End Term Work Assessment (ETWA) | Progressive Lab Assessment (PLA) | End Term Laboratory Assessment (ELA) | |
| **DMEE** | **PhD-ME-01** | **PCC** | **Optimization and Simulation** | **02** | **01** | **03** | **02** | **08** | **04** | **10** | **50** | **10** | **-** | **15** | **15** | **100** |

**G) 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.

## H) Theory Session Outcomes (TSOs) and Units:

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| *TSO 1a.* Explain the procedure to formulate a given optimization problem.<br>*TSO 1b.* Classify the optimization problems based on constraints and formulation.<br>*TSO 1c.* Explain the relationship between primal and dual problems.<br>*TSO 1d.* Apply the concept of duality to convert the primal problem into a dual problem<br>*TSO 1e.* Formulate given real-world problems as optimization problems. | **Unit-1.0 Optimization**<br>1.1 Optimal design problem formulation: Design variables, Constraints, Objective Function, Variable bounds<br>1.2 Classification of the optimization problems: Based upon constraints, nature of equations, etc.<br>1.3 Concept of duality: Primal and dual problems<br>1.4 Examples of optimization problems: Formulation of different types of problems as optimization problems | **CO1** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| *TSO2a.* Explain the optimality of a candidate solution of the single variable unconstrained optimization problem.<br>*TSO2b.* Bracket the optimum solution within a variable bound for the given problem.<br>*TSO2c.* Find the optimum solution of a single variable unconstrained problem using a direct search method.<br>*TSO2d.* Find the optimum solution of a single variable unconstrained problem using a gradient based method.<br>*TSO2e.* Apply the Newton-Raphson, bisection, and cubic search methods to find the optimal solution in the given single variable optimization problems. | **Unit-2.0 Single Variable Unconstrained Optimization**<br>2.1 Optimality Criteria for Single Variable Unconstrained Optimization<br>2.2 Bracketing methods: Exhaustive search method, Bounding Phase method<br>2.3 . Direct search methods: Interval Halving method, Quadratic Estimation Method<br>2.4 Gradient based methods: Newton Raphson method, Bisection method, Cubic search method. | **CO2** |
| TSO 3a. Explain the significance of optimality criteria in multivariable unconstrained optimization.<br>TSO 3b. Evaluate the optimality of a candidate solution of a given multivariable unconstrained problem.<br>TSO 3c. Describe the working of the evolutionary optimization method, simplex search method, and Powell's conjugate direction methods.<br>TSO 3d. Find the optimum solution to the given multivariable unconstrained problem using a direct search method.<br>TSO 3e. Find the optimum solution to the given multivariable unconstrained problem using a gradient-based methods. | **Unit-3.0 Multivariable Unconstrained Optimization**<br>3.1 Optimality Criteria for multivariable Unconstrained Optimization<br>3.2 Direct search methods: Evolutionary Optimization Method, Simplex Search method, Powell's Conjugate Direction method<br>3.3 Gradient based methods: Cauchy's method, Newton's method, Variable metric method | **CO3** |
| TSO 4a. Evaluate the optimality of a candidate solution to a constrained problem.<br>TSO 4b. Find an optimum solution to constrained optimization problem using a Transformation method.<br>TSO 4c. Find the optimum solution of constrained optimization problem using Variable Elimination method.<br>TSO 4d. Find optimum solution of constrained optimization problem using Generalized Reduced Gradient method. | **Unit- 4.0 Constrained Optimization**<br>4.1 Optimality Criteria for constrained Optimization<br>4.2 Transformation methods: Penalty Function Method, Method of Multipliers<br>4.3 Variable Elimination method<br>4.4 Generalized Reduced Gradient method<br>4.5 Evolutionary Optimization method<br>4.6 Real world applications | **CO4** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| TSO 4e. Find optimum solution of constrained optimization problem using Evolutionary optimization method.<br>TSO 4f. Apply Constrained optimization methods to real-world application problems. | | |
| TSO 5a. Explain the process of formulating a linear programming problem.<br>TSO 5b. Implement the simplex method to solve given linear programming problems.<br>TSO 5c. Apply the dual-phase method to solve linear programming problems.<br>TSO 5d. Analyze the sensitivity of optimum solution to the design variables. | **Unit- 5.0 Linear Programming Problems**<br>5.1 Formulation of Linear programming problem<br>5.2 simplex method<br>5.3 Dual Phase method<br>5.4 Sensitivity Analysis | **CO5** |

## I) Suggested Laboratory Experiences:

| Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment Titles | Relevant COs Number (s) |
|---|---|---|---|
| *LSO1.1.* Write a computer program for bracketing method<br>*LSO1.2.* Bracket an optimum solution of single variable unconstrained problem using the program. | 1. | Implement bracketing method using any programming tool and bracket optimum solution of a single variable problem | **CO2** |
| *LSO 2.1.* Write a computer program for direct search method for single variable unconstrained problem.<br>*LSO 2.2.* Find optimum solution of the single variable unconstrained problem using the program for direct search method | 2. | Implement a direct search method for single variable unconstrained problem and find optimum solution of the problem. | **CO2** |
| *LSO 3.1.* Write a computer program for gradient based search method for single variable unconstrained problem<br>*LSO 3.2.* find optimum solution of the single variable unconstrained problem using the program for Gradient search method | 3. | Implement a gradient based search method for single variable unconstrained problem and find optimum solution of the problem. | **CO2** |
| LSO 4.1. Write a computer program for direct search method for multivariable unconstrained problem. | 4. | Implement a direct search method for multivariable unconstrained problem and find optimum solution of the problem. | **CO3** |

| | | | |
|---|---|---|---|
| LSO 4.2. Find optimum solution of the multivariable unconstrained problem using the program for direct search method | | | |
| *LSO 5.1.* Write a computer program for a gradient-based search method for multivariable unconstrained problems.<br>*LSO 5.2.* find the optimum solution of the multivariable unconstrained problem using the program for gradient-based search method | 5. | Implement a gradient based search method for multivariable unconstrained problem and find optimum solution of the problem. | **CO3** |
| *LSO 6.1.* Write a computer program for a transformation method for a constrained problem.<br>*LSO 6.2.* Find optimum solution to the constrained problem using the program for transformation method | 6. | Implement a transformation method for a constrained optimization problem and find the optimum solution to the problem. | **CO4** |
| *LSO 7.1.* Write a computer program for an evolutionary optimization method for a constrained problem<br>*LSO 7.2.* Find the optimum solution to the constrained problem using the program for the evolutionary optimization method | 7. | Implement an evolutionary optimization method for a constrained optimization problem and find the optimum solution to the problem. | **CO4** |
| *LSO 8.1.* Write a computer program for a Simplex method for a linear programming problem<br>*LSO 8.2.* Find the optimum solution to the linear programming problem using the program for Simplex method | 8. | Implement the Simplex method for linear programming problems and find the optimum solution for the problem | **CO5** |

**J) Suggested Research Based Problems:**

i. Trucks are subjected to impact from the front side. Design FUPD of truck made of FRCP composite with optimum parameters.

ii. Gear box has a number of gears on multiple shafts. Find Optimum material configuration for gear box for reduction of speed in ratio 1:10

**K) Suggested Term Work (TW) and Self Learning (SL):**

**a. Assignment(s):**

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

**b. Seminar Topics:**

1. Classical optimization methods Vs modern optimization methods
2. Multi-objective optimization

**L) 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 Optimization | 10 |
| CO2 | Unit 2.0 Single Variable Unconstrained Optimization | 10 |
| CO3 | Unit 3.0 Multivariable Unconstrained Optimization | 10 |
| CO4 | Unit 4.0 Constrained Optimization | 10 |
| CO5 | Unit 5.0 Linear Programming Problems | 10 |
| **Total** | | **50** |

**M) 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.

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

a. Matlab
b. Siemens NX
c. Desktop/Laptop

**O) Suggested Learning Resources:**

**a) Books**

| S. No. | Titles | Author(s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 1 | Optimization for Engineering Design | Kalyanmoy Deb | 2nd Edition, Prentice Hall of India, ISBN 9788120346789 |
| 2 | Introduction to Optimum Design | J. S. Arora | 4th Edition, Elsevier, ISBN 978-0-12-800806-5 |
| 3 | Engineering Optimization Theory and Practice | Singiresu S Rao | John Wiley & Sons, ISBN:9781119454717 |
| 4 | Linear Programming and Extensions | G.B. Dantzig | 3rd ed, Princeton University Press, ISBN: 0691080003. |
| 5 | Non-Linear Optimization - Theory and Algorithms | L.C.W. Dixon | Birkhauser, Boston, ISBN: 9783764330200 |

### b) Online Educational Resources:

- https://archive.nptel.ac.in/content/storage2/courses/105108127/pdf/Module_1/M1L1slides.pdf

- https://www.sciencedirect.com/book/9780128211267/fundamentals-of-optimization- techniques-with-algorithms

### P) Course Curriculum Development Team

| S. No. | Name and Designation | E-mail Address |
|---|---|---|
| 1. | Dr. Vipin Kumar Tripathi (Coordinator) | vktripathi@nitttrbpl.ac.in |

| | |
|---|---|
| **A)** | **Course Title: Advances in Management** |
| **B)** | **Course Code: PhD-MS-01** |
| **C)** | **Pre- requisite Course (s): No pre-requisite** |

Deemed to be University under Distinct Category

**D) Rationale:** Management rarely faces issues that come with a specific title such as "marketing", "finance", or "HR". Rather, they deal with complex issues that cut across such functional categories. The content and curriculum of the course on Advanced Management are organised as an integrated learning process that enables learners to engage systematically with complex strategic issues. Designed to spark self-reflection, innovation, and collaboration, the course on Advanced Management is both a structured and deeply personal learning experience.

**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 |
|---|---|
| CO1 | Develop models to manage strategic human resource management practices for various organisations. |
| CO2 | Identify various parameters for Price, Place, and Promotion Decisions for various marketing Mixes. |
| CO3 | Provide financial solutions for business problems using various financial tools for financial data sets wrt sustainability, technological disruption, and global business operations. |
| CO4 | Implement Strategic Management Processes for various companies. |

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

| Board of Study | Course Category and Code | Course Titles | Teaching & Learning Scheme (Hours/Week) | | | | | | Assessment Scheme (Marks) | | | | | | Total Marks (TA+TWA+LA) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Theory Component (TC) | | Lab Instruction (LI) | Term Work (TW) | Total Hours/Week (TC+LI+TW) (For 15 Weeks) | Total Credits (C) | Theory Assessment (TA) | | Term work Assessment (TWA) | | Lab Assessment (LA) | | |
| | | | Input (I) | Tutorial (T) | | | | | Progressive Theory Assessment(PTA) | End Theory Assessment (ETA) | Progressive Term Work Assessment | End Term Work Assessment (ETWA) | Progressive Lab Assessment(PLA) | End Laboratory Assessment(ELA) | |
| | PhD-MS-01 | **Advances in Management** | **03** | **02** | **01** | **02** | **08** | **04** | **10** | **50** | **10** | **10** | **10** | **10** | **100** |

**G) Course Curriculum Detailing:** For attainment of course outcomes, the **learners** expected to undergo various activities through classroom, workshops term/ work, self- learning/ field sessions.

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

| Major Theory Session Outcomes (TSOs) | Units | Relevant CO Number(s) |
|---|---|---|
| TSO 1a. Differentiate between the given types of SHRMPs<br>TSO 1b. Write the detailed process of designing the given types of SHRMP<br>TSO 1c. Identify the Impact Evaluation Criterias of various SHRMP for the given organization<br>TSO 1d. Apply the Impact Evaluation Criterias of various SHRMP based on the performance of the given organization.<br>TSO 1e. Develop a model to manage strategic human resource management practices for the given organization<br>TSO 1f. Explain the recent developments/ trends in the given strategic human resource development practice | **Unit-1.0 Strategic Human Resource Management**<br>1.1 Different SHRMPs<br>1.2 Process of designing various SHRMP<br>1.3 Impact Evaluation Criterias of various SHRMP based on the performance of the organization<br>1.4 Process of contextual model development for SHRMPs<br>1.5 Advancements in SHRMPS | **CO1** |
| TSO 2a. Explain the marketing fundamentals for the given situation.<br>TSO 2b. Explain Marketing Strategy and Practice for the given product.<br>TSO 2c. Identify the Marketing Research Methods for the given product.<br>TSO 2d. Develop a marketing mix for the given product<br>TSO 2e. Explain Consumer Behaviour and Product Decisions for the given product<br>TSO 2f. Identify the parameters of the given Price Place And Promotion Decisions<br>TSO 2g. Explain the role of Strategic Marketing In Public Policy Decisions | **Unit-2.0 Strategic Marketing Management**<br>2.1: Marketing Fundamentals<br>2.2: Marketing Strategy and Practice<br>2.3: Marketing Research Methods<br>2.4: Consumer Behaviour and Product Decisions<br>2.5: Price Place And Promotion Decisions<br>2.5: Strategic Marketing In Public Policy Decisions | **CO2** |
| TSO 3a. Outline the scope of SFM<br>TSO 3b. List the objectives of SFM<br>TSO 3c. Evaluate the relationship between corporate strategy and financial strategy.<br>TSO 3d. Identify the role of the financial manager in strategic decision-making.<br>TSO 3e. Explain the importance of financial planning in a strategic context. | **Unit-3.0 Strategic Financial Management**<br>**3.1** Fundamentals of SFM<br>**3.2** Key elements of a financial strategy,<br>**3.3** Steps in financial planning,<br>**3.4** Types of financial plans<br>**3.5** interface of financial policy and strategic management. | **CO3** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant CO Number(s) |
|---|---|---|
| TSO 3f. Differentiate between the given types of FP (strategic/ tactical/operational)<br>TSO 3g. Explain the risk and uncertainty in the given investment decision.<br>TSO 3h. Apply risk analysis techniques to evaluate the given capital budgeting proposal.<br>TSO 3i. Analyze the given investment decision on the basis of NPV, IRR, PBP, PI<br>TSO 3j. List the benefits of using financial models in decision-making.<br>TSO 3k. Differentiate between the given types of financial models.<br>TSO 3l. Outline the steps involved in building a financial model.<br>TSO 3m. Provide financial solutions for business problems using appropriate financial tool for the given financial data wrt sustainability, technological disruption, and global business operations.<br>TSO 3n. Identify the implications of the special topics for long-term corporate success. | **3.6** Risk analysis techniques in capital budgeting,<br>**3.7** Applications in Investment decisions<br>**3.8** Financial Models: Role,types,developing financial models<br>**3.9** Key financial tools and techniques<br>**3.10** Special Topics in SFM: Digital Finance, Green Finance/ESG, International Financial Management, Corporate Restructuring & Turnaround Management | |
| TSO 4a. Define Strategy/ strategic management<br>TSO 4b. Differentiate Strategy, Strategic Plan and Tactics for the given situation.<br>TSO 4c. Explain Strategic Planning for the given business<br>TSO 4d. Develop a strategic vision for the given firm.<br>TSO 4e. Communicate the developed strategic vision for the given firm.<br>TSO 4f. Link the mission statement with the Core Values for the given company<br>TSO 4g. Develop a Strategic Management Process for the given company<br>TSO 4h. Explain Strategy Implementation for the developed strategy.<br>TSO 4i. Implement Strategic Management Process for the given company. | **Unit -4.0: Strategic Management**<br>4.1 Strategic Management<br>4.2 Strategy, Strategic Plan and Tactics<br>4.3 Strategic Planning<br>4.4 Developing and Communicating the Strategic Vision<br>4.5 Developing Company's Mission Statement and Linking it with Core Values<br>4.6 Strategic Management Process<br>4.7 Strategy Implementation | **CO4** |

## I) Suggested Laboratory Experiences: NA

## J) Suggested Research Based Problems

## K) Suggested Term Work (TW):

### a. Assignment(s):

1. Analyze the importance of SHRM in employee training and development. How does focusing on skill-building and career growth benefit both the individual and the organization?
2. Describe how SHRM contributes to an organization's ability to adapt to changing business environments. Provide examples of how HR strategies can support flexibility and innovation.
3. Explain how strategic marketing management drives business growth by aligning marketing goals with organizational objectives. Provide examples of successful marketing strategies that enhance competitive advantage.
4. Analyze the significance of positioning and branding in strategic marketing. How does effective branding contribute to building a strong market presence and customer loyalty?
5. Analyze the process of strategic investment decision-making and risk assessment. How does evaluating risk factors influence the selection of projects and capital allocation?
6. Capital Structure and Cost of Capital: Discuss the impact of capital structure on a company's financial health. How does understanding the cost of capital help in determining the optimal mix of debt and equity?
7. Explain the role of strategic planning in shaping an organization's vision and mission. How does a clear strategy guide the organization toward achieving its long-term goals?
8. Analyze the role of core competencies in gaining a competitive advantage. How does focusing on unique strengths differentiate an organization in a competitive market?

### b. Seminar Topics:

- Innovation as a Strategic Tool
- Corporate Social Responsibility and Strategy
- Strategic Planning in Uncertain Environments
- Globalization and Strategic Management
- The Role of Digital Transformation in Strategic Management
- Sustainable Business Strategies
- Strategic Alliances and Partnerships
- SHRM and Organizational Culture
- Employee Engagement and Retention Strategies
- Diversity and Inclusion as a Strategic HR GoalTalent Acquisition and Retention in a Competitive Market
- The Role of HR Analytics in Strategic Decision-Making
- Performance Management Systems Workforce Planning in SHRM
- Strategic Marketing

### c. Micro Projects topics:

- Develop a green strategy for a small business to improve sustainability.
- Create a crisis response plan for a hypothetical company.
- Design a small-scale engagement survey and action plan to improve workplace motivation.
- Propose an entry strategy for a small business aiming to expand into a new market.
- Create a basic D&I strategy for a small organization, highlighting measurable goals.

- Design an onboarding program for new hires to align them with company culture and strategy.
- Conduct a comparative analysis of two brands, highlighting their marketing strategies.
- Create detailed customer personas for a product based on research and market analysis.
- Design a skill development roadmap for employees in a department.
- Analyze and suggest repositioning strategies for a local business to attract new customers.
- Conduct a comparative analysis of two brands, highlighting their marketing strategies.

**L) 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 Strategic Human Resource Management | 12 |
| CO2 | Unit-2.0 Strategic Marketing Management | 12 |
| CO3 | Unit-3.0 Strategic Financial Management | 12 |
| CO4 | Unit -4.0: Strategic Management | 14 |
| **Total** | | **50** |

**M) Suggested Instructional/ Implementation Strategies:** NA

**N) Major Equipment, Tools and Software for Laboratory and Research Work:** NA

**O) Suggested Learning Resources:**

**a) Books**

| S. No. | Titles | Author(s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 1. | Exploring Strategy: Text and Cases | Fred R. David, Forest R. David | Pearson, ISBN: 9780135173947 |
| 2. | Strategic Human Resource Management (SHRM) | Michael E. Porter | Free Press, ISBN: 9781416595847 |
| 3. | Strategic Human Resource Management: A Guide to Action | Jeffrey A. Mello | Cengage Learning, ISBN: 9781133492127 |
| 4. | Strategic HRM: The Key to Improved Business Performance | Michael Armstrong | Kogan Page, ISBN: 9780749453756 |
| 5. | Strategic Marketing Management (SMM) | Dave Ulrich | Harvard Business Review Press, ISBN: 9780875847191 |
| 6. | Marketing Management | Alexander Chernev | Cerebellum Press, ISBN: 9781936572527 |
| 7. | Strategic Market Management | Philip Kotler, Kevin Lane Keller | Pearson, ISBN: 9780133856460 |
| 8. | Principles of Marketing | David A. Aaker, Christine Moorman | Wiley, ISBN: 9781119392200 |

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

- https://ocw.mit.edu/courses/15-902-strategic-management-i-fall-2006/
- https://learn.saylor.org/mod/page/view.php?id=20630
- https://courses.lumenlearning.com/wmopen-principlesofmanagement/chapter/the-role-of-strategy-in-management/
- https://learn.saylor.org/mod/book/view.php?id=70149
- https://ocw.mit.edu/courses/15-660-strategic-hr-management-spring-2003/
- https://learn.saylor.org/course/view.php?id=687

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