M.Tech Manufacturing Engineering

Curriculum and Syllabus
(2021 Admission Onwards)
M.TECH –MANUFACTURING ENGINEERING
Department of Mechanical Engineering

Manufacturing Sector is the engine of growth for our country and it provides a stable economy. According to the technology road map 2035, the manufacturing sector in India needs to grow through adoption of technology platforms which include nano engineering, additive manufacturing, adaptive automation, precision manufacturing and sustainable manufacturing. The industry needs the skill and creativity to manufacture complex, high specialization products. This program provides an in depth understanding of wide range of domains like advanced manufacturing processes, micro and nano manufacturing, additive manufacturing, lean manufacturing, Internet of things, machine learning and smart factory concepts and is an important link for industrial competitiveness.

The syllabus for various courses has been designed in general to introduce the application of analytical and quantitative methods in manufacturing and to train the students to develop skills in the utilization of the modern tools such as simulation, optimization, statistical data analysis, and finite element analysis. During the course of study, the students will acquire knowledge and skills to solve practical problems encountered in manufacturing.
M Tech Manufacturing Engineering

1.0 Mission of the Department

| M1 | To develop in each student, a profound understanding of fundamentals, motivation for continuous learning, and practical problem-solving skills for building a successful career. |
| M2 | To create and share technical knowledge and collaborate with Industry and Institutions for the betterment of Society. |
| M3 | To imbibe ethical values, leadership skills and entrepreneurial skills in students. |
| M4 | To sustain a conducive environment to involve students and faculty in research and development. |

2.0 Program Educational Outcomes (PEOs)

| PEO1 | Develop and implement innovative methods and models for improving performance of manufacturing systems |
| PEO2 | Apply smart manufacturing concepts for enhancing manufacturing and supply chain operations |
| PEO3 | Conduct research by following ethical practices with intellectual integrity to provide cost-effective and sustainable solutions for the industrial and societal problems |
| PEO4 | Collaborate and function effectively as an individual and team member in a professional career and/or entrepreneurship |

3.0 Program Outcomes (POs)

| PO1 | Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program |
| PO2 | An ability to write and present a substantial technical report/document. |
| PO3 | An ability to independently carry out research/investigation and development work to solve practical problems |
| PO4 | Develop and analyse the manufacturing processes and systems, to improve their performances using modern tools and approaches. |
| PO5 | Apply the knowledge of Science and Engineering to develop materials and processes for the strategic needs of Industry and Society |
| PO6 | Implement automation and IoT concepts for process improvement and control |
## Curriculum

### First Semester

<table>
<thead>
<tr>
<th>Course Code</th>
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* Non-credit course

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*Can opt for NPTEL/Swayam courses with the prior approval from the Department

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Credits 16

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Course Objectives:
1. Expose the student to random experiments, probability and counting methods.
2. Elucidate random variables, their functions, and random processes
3. Familiarize hypotheses testing, regression and ANOVA.
4. Develop skills in employing numerical methods for solving differential equations

Course Outcomes:

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<th>CO Description</th>
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<tr>
<td>CO01</td>
<td>Understand concepts of probability, random variables and their properties</td>
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<tr>
<td>CO02</td>
<td>Formulate fundamental probability distribution and density functions, as well as functions of random variables, random process.</td>
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<tr>
<td>CO03</td>
<td>Demonstrate skill of performing hypotheses testing, analysis of variance and linear regression.</td>
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<tr>
<td>CO04</td>
<td>Apply finite difference and finite element methods to obtain solution of partial differential equation.</td>
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CO-PO Mapping:

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Skills Acquired:
Solve problems involving random variables, distributions and random process. Build regression models, test hypotheses, perform ANOVA. Solve partial differential equations using numerical methods.

Syllabus:
Review of Probability Concepts
Random Variables: Single and multiple variables (discrete, continuous, and mixed), important distributions, functions of random variables, joint distributions, sum of random variables, moment-generating functions, random vectors, and inequalities; law of large numbers and the central limit theorem.
Statistical Inference: Point and interval estimation, Estimation Methods, Hypothesis testing, Goodness of fit, Bayesian statistics, Nonparametric methods. Linear models - Sample inference, one way ANOVA, Multiple comparisons, Linear Regression.
MATLAB applications: Generate random variables, Simulate probabilistic systems, ANOVA and solving PDE using FDM and FEM.
Text Books / References:


Evaluation Pattern:

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*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,
Course Objectives:
1. To familiarize the fundamentals of advanced casing processes and to understand the basic concepts of solidification.
2. To give exposure to various advanced welding techniques and to be familiarize with welding standards, weldability of different materials.
3. To select and apply various advanced machining processes for specific applications and to understand the optimization of parameters to obtain the desired machining quality.
4. To understand the concepts of severe plastic deformation and High energy rate forming and to be familiarize with basics of stress strain relations and the deformation mechanisms.

Course Outcomes:

<table>
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<tr>
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<th>CO Description</th>
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<tbody>
<tr>
<td>CO01</td>
<td>Select and apply suitable advanced casting techniques to obtain the desired quality and to understand the concepts of solidification.</td>
</tr>
<tr>
<td>CO02</td>
<td>Perform suitable advanced welding techniques to obtain the desired weld joint and to understand the effect of welding parameters on weld quality.</td>
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<tr>
<td>CO03</td>
<td>Select and apply suitable advanced machining processes and optimize its parameters to achieve the desired machining characteristics.</td>
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<tr>
<td>CO04</td>
<td>Examine the stress strain relations and the deformation mechanisms and select appropriate severe plastic deformation and High energy rate forming processes to get the near net shape of the product.</td>
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CO-PO Mapping:

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Skills Acquired:

Ability to select the appropriate casting, welding processes, advanced machining processes, severe plastic deformation and high energy rate forming processes & to optimize its process parameters to obtain the desired quality.

Syllabus:


Text Books/ References:


Evaluation Pattern:

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*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,
Course Objectives:
1. To familiarize the fundamentals of thermodynamics of nucleation and kinetics of growth.
2. To select appropriate materials and manufacturing techniques to meet end applications.
3. To understand the benefits of high-performance energy materials and its fabrication route.
4. To provide materials’ structure and its properties with the aid of advanced characterization techniques.

Course Outcomes:

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<td>Gain knowledge about thermodynamics of nucleation and strengthening mechanisms</td>
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<tr>
<td>CO02</td>
<td>Analyse (and select) suitable materials and methods to meet high end and light weight application</td>
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<tr>
<td>CO03</td>
<td>Acquire knowledge in high performance materials and techniques</td>
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<tr>
<td>CO04</td>
<td>Analyse interrelationships and interdependence between processing, structure, properties, and performance using advanced material characterization techniques</td>
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Skills Acquired:

Concept of advanced materials science and its characterization up to the atomic level, Difference between conventional and advanced materials, Thermodynamics and equipment details for advanced materials.

Syllabus:

Introduction to advanced materials science, thermodynamics of homogeneous and heterogeneous nucleation and kinetics of growth, non-equilibrium freezing, segregation, nucleation in the solid state, diffusion in solids, strengthening mechanism and principles. Material science and processing of light materials- aluminium, titanium, high strength steel, magnesium alloys, super alloys, high temperature materials, ceramic and carbon composites, cellular solids, metal foams.

Processing of nano, bio and composite materials and their manufacturing science, high performance polymers, recent advances in material development- functionally gradient materials and characterization, carbon nanostructures, graphenes, fullerenes, next generation battery and fuel cell materials. Introduction to special processes- High energy ball milling, thin films and vapour depositions, laser and other high intensity beam processes, sol-gel technique, synthesis and additive manufacturing.

Introduction to advanced materials characterization techniques- Scanning electron microscopy, transmission electron microscopy and energy dispersive analyses, X-ray diffraction, atomic force microscopy, Fourier-transform infrared spectroscopy, Field array NDT techniques for futuristic materials.
Challenges and scope for new and advanced materials, case studies related to design-materials selection – manufacturing models.

Text Books/References:


Evaluation Pattern:

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</table>

*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,
Course Objectives:
- Introduce basics of the metal cutting mechanism of metal cutting operations
- Review fundamental concepts of free and forced vibrations
- Introduce basics of modal analysis - analytical and experimental
- Inculcate chatter stability analysis of machine tools by introducing self-excited machine tool vibrations
- Introduce advanced topics of high-performance machining / high-speed machining

Course Outcomes:

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<tr>
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<tbody>
<tr>
<td>CO01</td>
<td>Understand the basics of modeling metal cutting operations and identify various parameters affecting metal cutting processes</td>
</tr>
<tr>
<td>CO02</td>
<td>Formulate a mathematical model of a system to study its dynamic characteristics considering natural frequency, damping factors, and mode shapes</td>
</tr>
<tr>
<td>CO03</td>
<td>Perform stability analysis using Frequency Response Functions (FRF) and Plots, and Stability Lobe Diagrams (SLD) for turning and milling processes</td>
</tr>
<tr>
<td>CO04</td>
<td>Familiarize with various sensors and signal processing methods to monitor and control the machining processes</td>
</tr>
<tr>
<td>CO05</td>
<td>Conduct experimental investigations to study the dynamic behavior of metal cutting processes and improve their stability</td>
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CO-PO Mapping:

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Skills Acquired:
Cutting Force measurement using cutting tool dynamometers; Gain user-level familiarity with machine tool dynamics testing equipment and machining process monitoring equipment; Conduct Modal Analysis; Predict Chatter using Frequency Response Functions; Familiarise with software tools for sensor signature processing.

Syllabus:
Machining forces: Systems of cutting tool geometry - ASA, ORS and NRS systems - Cutting force components in turning, milling, and drilling - Construction of Merchant Circle Diagram - Cutting power consumption and specific energy requirement - Analytical models for estimation of cutting forces in orthogonal and oblique cutting – Measurement of cutting forces.


Machining issues in Advanced machining processes: High-Speed Machining, Thin-wall machining, and High-performance machining - Machining economics and optimization.

Lab Component: Cutting Force / Cutting temperature Measurement, Chip Morphological studies, Tool wear and Tool life studies, Modeling and Simulation of metal cutting processes, Modal analysis, and Modal parameter extraction, optimize machining parameters using stability lobe plots, Process monitoring and control using sensors and signal processing.

Text Books/ References:

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*Can be assignments, tutorials, quizzes, term paper, experiments, mini projects presentations, etc.,
Course Objectives:

1. To provide the interdisciplinary knowledge in mechanical, electric, and control subsystems for developing automated manufacturing systems
2. To introduce various sensing, actuating and control elements of an automated system
3. To provide hands on experience on automated system design using Hydraulics, Pneumatics, PLC, Microcontrollers and Robotics.

Course Outcomes:

<table>
<thead>
<tr>
<th>CO01</th>
<th>Design and simulate fluid power circuits to automate manufacturing processes/systems</th>
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<tbody>
<tr>
<td>CO02</td>
<td>Select and integrate various components of automation like sensors, actuators, PLC and robots for a given application</td>
</tr>
<tr>
<td>CO03</td>
<td>Develop microcontroller programs to monitor and control the manufacturing systems</td>
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<tr>
<td>CO04</td>
<td>Design and develop an automated system for a given industrial application</td>
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CO-PO Mapping:

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Skills Acquired:

Design of fluid power circuits for automation, Programing PLC & Robots and Programming Micro controllers for interfacing sensors.

Syllabus:


Introduction to IoT and IIoT Concepts, Data Monitoring using Arduino/Raspberry Pi: Basic structure - Input / Output processing - Programming - Mnemonics Timers, Internal relays and counters – A/D, D/A Conversion - Analog input / output, Programming and interfacing with Sensors in manufacturing applications. Supervisory Control and Data Acquisition (SCADA)-Data Acquisition- Remote Telemetry Units- Human Machine Interface (HMI) and)-Communications Network- implementation examples in manufacturing.

Lab Practice:
Fluid Power Circuits: Design and Simulation of fluid power circuits for a given automated system requirement. PLC Programming: PLC control of electro-pneumatic and electro-hydraulic systems, Interfacing digital input and output field devices with PLC hardware. Exercises on sensor integration using Arduino/Raspberry Pi. Robot Programming: Industrial robot programming for material handling and processing applications

Text Books/ References:

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</table>

*Can be assignments, tutorials, quizzes, term paper, experiments, mini projects, presentations, etc.,
Course Objectives:

1. Introduce basic python programming and concepts
2. Enable python programming skills for scientific computing
3. Provide hands on programming for practical prediction-based applications

Course Outcomes:

<table>
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<tr>
<th>CO01</th>
<th>Understand the given programming language constructs.</th>
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<td>CO02</td>
<td>Develop simple programs with scripts and control statements.</td>
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<tr>
<td>CO03</td>
<td>Illustrate problems machine learning methods</td>
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<tr>
<td>CO04</td>
<td>Apply data analytics using python scientific packages.</td>
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CO- PO Mapping:

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Skills Acquired:

Problem solving of the physical systems/mathematical models using Python programming

Syllabus:

Introduction to Python: motivation for learning Python in various engineering applications. The concept of data types: variables, assignments; immutable variables; numerical types; arithmetic operators and expressions; comments in the program; understanding error messages; Conditions, boolean logic, logical operators: ranges;

Control statements: if-else, loops (for, while); Continue; pass; break; short-circuit (lazy) evaluation. Reading/writing text and numbers from/to a file; creating and reading a formatted file. Lists, tuples, Set and dictionaries: basic list operators, replacing, inserting, removing an element; searching and sorting lists; adding and removing keys, accessing and replacing values; traversing dictionaries.

Python packages for scientific computing: Numpy, SciPy, Pandas, Scikit-learn. Data analysis with python; Concepts of data preparation; Time series data analysis. Introduction to machine learning; Extraction of features for machine learning methods; Linear regression, logistic regression, decision tree, random forest algorithm. Data visualization.

Text Books/ References:


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*Can be assignments, tutorials, quizzes, term paper, experiments, mini projects presentations, etc.,
Course Objectives:

1. To practise the fabrication of a Metal Matrix Composite (MMC) sample using a stir casting process.
2. To familiarize the fabrication of samples using casing processes and analyze its microstructure.
3. To give exposure to the fabrication of metal welded joint using various materials by GTA / GMA welding processes and analyze the welded joint quality.
4. To practise the machining of various metals using EDM by varying its process parameters to obtain the desired machining quality.

Course Outcomes:

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<th>CO Description</th>
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<tbody>
<tr>
<td>CO01</td>
<td>Fabricate a MMC casting sample to obtain the desired quality and inspect its microstructure concerning various process parameters.</td>
</tr>
<tr>
<td>CO02</td>
<td>Perform fabrication of sand mould casting sample and understand the effect of cooling rate on the microstructure of casted sample.</td>
</tr>
<tr>
<td>CO03</td>
<td>Fabricate a welded joint of different materials using the GTA and GMA process and analyze the microstructure of welded joint by varying the process parameters.</td>
</tr>
<tr>
<td>CO04</td>
<td>Machining various metal samples using the EDM process and analyze the sample for MRR or surface roughness concerning various process parameters.</td>
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CO-PO Mapping:

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Skills Acquired:

Prepare a casting / welding samples and analyze the variation in microstructure by varying the process parameters. Machining of different materials using advanced machining processes and optimize its parameters to get desired MRR or surface finish.

List of Exercises:

1. Preparation of Metal Matrix Composite (MMC) sample using various metallic and ceramic reinforcements by varying process parameters using the stir casting process.
2. Analyze the microstructure of MMC samples and mechanical properties such as hardness and tensile strength.
3. Preparation of a conventional sand mould casting and analyze the variation in the microstructure of the casting sample by varying the cooling rate of the casting.
4. GTA welding of various metal samples and analyzing its microstructure after cutting the cross-section of weld bead.
5. Analyze the effect of weld quality due to GTAW process parameters such as welding current, travel speed and stand-off distance.
6. GMA welding of various metal samples and analyzing their microstructure after cutting the weld bead cross-section and interpreting it.
7. Analyze the effect of weld quality due to GMAW process parameters such as welding current, travel speed and stand-off distance.
8. Measurement of weld bead geometry elements using macrostructure analysis.
9. Machining various metal samples using an EDM machine with various process parameters.
10. Analyze EDM machined sample surface finish with respect to MRR and machining parameters.
11. Measure the tool wear experimentally in the EDM process and develop correlation between process parameters and tool wear.

**Evaluation Pattern:**

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*Can be assignments, tutorials, quizzes, term paper, experiments, mini projects presentations, etc.,
Course Objectives:
1. Understanding the various types of advanced micromachining processes used to manufacture miniature devices
2. Introduce Conventional and Non-conventional micromachining, forming, and finishing processes.
3. Inculcate the concepts of precision and ultraprecision machining techniques to produce components with high dimensional and form accuracy
4. Impart knowledge on manufacturing of MEMS devices
5. Machinability studies using precision milling machines, ultra-precision high-speed machining center, and wire EDM processes
6. Demonstrate the photolithographic process to fabricate miniature devices

Course Outcomes:

<table>
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<th>CO Description</th>
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<tr>
<td>CO01</td>
<td>Recognize the need and identify suitable applications for traditional and advanced micromachining, forming joining, and deposition processes.</td>
</tr>
<tr>
<td>CO02</td>
<td>Understand the metal removal mechanisms in ultra-precision machining and appreciate the use of diamond turning, diamond grinding, and polishing process to make devices with good dimensional and form accuracy</td>
</tr>
<tr>
<td>CO03</td>
<td>Design the fabrication process using Photolithography / LIGA to make MEMS devices</td>
</tr>
<tr>
<td>CO04</td>
<td>Select a suitable Metrology for measurement of dimensional, form, and surface integrity of components manufacturing using micro and nano Manufacturing</td>
</tr>
<tr>
<td>CO05</td>
<td>Conduct experimental studies in micro/precision milling machines, precision high-speed machining centers, and EDM to analyze the process capability.</td>
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CO-PO Mapping:

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Skills Acquired:

Conduct machinability studies in precision and micro machining machines; Design of MEMS devices; Dimensional and form Measurement of micro and nano features.

Syllabus:


**Lab Practice:**
- Micromachining using the precision milling machine
- Machining studies using Precision and Ultra-precision machining process.
- Study of Advanced machining process: EDM
- Design and Fabrication of MEMS devices
- Surface Modification using PVD/CVD Techniques
- Metrology: Microscopy, AFM, non-contact probes, CMM

**Textbooks/ References:**


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*Can be assignments, tutorials, quizzes, term paper, experiments, mini projects presentations, etc.,
Course Objectives:
1. To impart knowledge on basic concepts of lean manufacturing to continuously improve the productivity
2. To familiarize lean tools for improvement and integrate them with the organization’s strategies to personalize the lean process.

Course Outcomes:

<table>
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<th>CO</th>
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<tbody>
<tr>
<td>CO01</td>
<td>Identify key requirements and concepts in lean manufacturing.</td>
</tr>
<tr>
<td>CO02</td>
<td>Initiate a continuous improvement change program in a manufacturing organization.</td>
</tr>
<tr>
<td>CO03</td>
<td>Analyze and improve a manufacturing system by applying lean manufacturing tools</td>
</tr>
<tr>
<td>CO04</td>
<td>To achieve lean six sigma quality and sustainability in a manufacturing system</td>
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Skills Acquired:
Capability to understand the value stream and non-value addition of a manufacturing/business system, To apply the concepts of TAKT TIME, To practice KAIZEN concept in manufacturing systems. Students can get a lean certification and do work independently as consultants.

Syllabus:


Ergonomics-as enabler of lean manufacturing, Ergonomic consideration at work, Principles related to: the use of human body, the arrangement of workplace, the design of tools and equipment
The impact of Industry 4.0 on soft lean practices, The facilitating effects of lean manufacturing on Industry 4.0 implementation, Effect of environmental factors on the integration of Industry 4.0 and lean manufacturing, Study on the performance implications of Industry 4.0 and lean manufacturing integration.

**Text Books/ References:**


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*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,
Course Objectives:
1. To impart knowledge on the fundamentals of manufacturing and Industry 4.0
2. To give the exposure on machine learning algorithms and data analytics.

Course Outcomes:

<table>
<thead>
<tr>
<th>CO</th>
<th>CO Description</th>
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</thead>
<tbody>
<tr>
<td>CO01</td>
<td>Gain the knowledge on various aspects of manufacturing systems and Industry 4.0</td>
</tr>
<tr>
<td>CO02</td>
<td>Apply the smart factory concepts in manufacturing industries</td>
</tr>
<tr>
<td>CO03</td>
<td>Apply the various machine learning algorithms to predict the performance</td>
</tr>
<tr>
<td>CO04</td>
<td>Evaluate the performance on the factory through data analytics and machine</td>
</tr>
<tr>
<td></td>
<td>learning algorithms</td>
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CO-PO Mapping:

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Skills Acquired:
Smart Factory Concepts, Data Management, Data Analytics, Machine Learning Algorithms

Syllabus:


Text Books/References:


Evaluation Pattern:

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*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,
Course Objectives
1. To develop an understanding of the basic framework of research process
2. To identify various sources of information for literature review and data collection
3. To develop an understanding of the ethical dimensions of conducting applied research

Course Outcomes:

<table>
<thead>
<tr>
<th>CO</th>
<th>CO Description</th>
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</thead>
<tbody>
<tr>
<td>CO01</td>
<td>Understand research problem formulation</td>
</tr>
<tr>
<td>CO02</td>
<td>Analyse research related information</td>
</tr>
<tr>
<td>CO03</td>
<td>Follow research ethics</td>
</tr>
<tr>
<td>CO04</td>
<td>Understand that today’s world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.</td>
</tr>
<tr>
<td>CO05</td>
<td>Understanding that when IPR would take such important place in growth of individuals &amp; nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general &amp; engineering in particular</td>
</tr>
<tr>
<td>CO06</td>
<td>Understand that IPR protection provides an incentive to inventors for further research work and investment in R &amp; D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits</td>
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CO-PO Mapping:

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<tr>
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Skills Acquired:
Research problem identification, solution strategies, research ethics, report writing, IPR

Syllabus:

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Effective literature studies approaches, analysis Plagiarism, Research ethics.
Effective technical writing, how to write report, Paper, Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee


New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Text Books/References:

Evaluation Pattern:

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<th>Evaluation Components</th>
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</table>

*Can be assignments, tutorials, quizzes, term paper, experiments, mini projects presentations, etc.,
Course Objectives:
1. Introduce fundamental understanding of the principles of CAD/CAM, including engineering drawing, geometric and surface, and feature-based design
2. Familiarize with CNC machine tools and their construction, and tooling for performing a variety of metal cutting operations
3. Inculcate the programming skills to write CNC programs using Computer-Aided Manufacturing (CAM) software and integrate with CNC machine and perform machining operation in a CNC machine tool

Course Outcomes:

<table>
<thead>
<tr>
<th>Co</th>
<th>CO Description</th>
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</thead>
<tbody>
<tr>
<td>CO01</td>
<td>Understand the construction of CNC machine tool and select suitable tooling for manufacturing</td>
</tr>
<tr>
<td>CO02</td>
<td>Read the blueprints and develop process plans for manufacturing the components in CNC turning and machining centers</td>
</tr>
<tr>
<td>CO03</td>
<td>Create 3D models using CAD tools and generate CNC programs using CAM software, integrate the program with the CNC turning/machining center</td>
</tr>
<tr>
<td>CO04</td>
<td>Familiarize with the High-Speed Machining process and its tooling and generate CNC programs for the precision components</td>
</tr>
<tr>
<td>CO05</td>
<td>Perform machining operations in CNC machines, measurements using advanced metrology and sensors, following safety standards, and effectively communicate the outcomes of the experimental work</td>
</tr>
</tbody>
</table>

CO-PO Mapping

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</table>

Skills Acquired:
Develop Process Plans; Manual Part programming for turning and milling operations; CNC Code generation using CAM software

Syllabus:
Introduction to CAM - Types, construction, tooling of CNC machines - Blueprint reading and process planning - CNC Manual Part Programming - Programming using CAM software for CNC turning and machining center - Machining practices – High-Speed Machining Centre: tooling, programming – Inspection of machined components using advanced metrology and sensors.

Test Books/References:
2. Machine tool manuals
3. Lab manual
Evaluation Pattern:

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</table>

*Can be assignments, tutorials, quizzes, term paper, experiments, mini projects presentations, etc..
Course Objectives:

1. The primary objective of the courses is to make the students proficient in the use of discrete event simulation software for modeling and simulation of the manufacturing system.
2. The students are expected to model real-world manufacturing systems and to analyze the system for improvement using a discrete event simulation package.

Course Outcomes:

<table>
<thead>
<tr>
<th>COs</th>
<th>CO Description</th>
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</thead>
<tbody>
<tr>
<td>CO01</td>
<td>Appreciate the role of discrete-event simulation and modeling and their application in the manufacturing environment.</td>
</tr>
<tr>
<td>CO02</td>
<td>Analysis of simulation input data using statistical tools and fit the input data into a suitable probability distribution for developing simulation models of manufacturing systems.</td>
</tr>
<tr>
<td>CO03</td>
<td>Simulation modeling of complex manufacturing systems using discrete event simulation software package.</td>
</tr>
<tr>
<td>CO04</td>
<td>Interpret and analyze the simulation results of a real-world problem, identify bottlenecks, and provide suggestions for performance improvement.</td>
</tr>
</tbody>
</table>

CO-PO Mapping:

<table>
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<th>COs</th>
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</table>

Skills Acquired:
Performance Modelling of Manufacturing Systems using Discrete Event Simulation Software; Bottleneck analysis

Syllabus:


Text Books/References:

4. Lab Manual
**Evaluation Pattern:**

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<th>Evaluation Components</th>
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<tbody>
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<tr>
<td>End Semester</td>
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</tbody>
</table>

*Can be assignments, tutorials, quizzes, term paper, experiments, mini projects presentations, etc.,*
Course Objectives:
1. To make students understand the wide range of additive manufacturing processes, capabilities and materials
2. To provide comprehensive knowledge on the various software tools and techniques that enable additive manufacturing.
3. To make the students learn to create physical objects that satisfies product development/prototyping requirements, using additive manufacturing processes.

Course Outcomes:

<table>
<thead>
<tr>
<th>CO</th>
<th>CO Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO01</td>
<td>Demonstrate appropriate levels of understanding on the principles of additive manufacturing processes</td>
</tr>
<tr>
<td>CO02</td>
<td>Demonstrate competency in the use of materials for additive manufacturing processes</td>
</tr>
<tr>
<td>CO03</td>
<td>Demonstrate the methodology of CAD tools and CAD interface with additive manufacturing systems</td>
</tr>
<tr>
<td>CO04</td>
<td>Identify suitable additive manufacturing process, define optimum process parameters and develop physical prototypes using suitable additive manufacturing systems.</td>
</tr>
</tbody>
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CO-PO Mapping:

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</tbody>
</table>

Skills Acquired:
Selection of suitable additive manufacturing technique for a given application, finishing of additive manufactured part, CAD data transfer to additive manufacturing, technology for metal additive manufacturing

Syllabus:

Introduction: Methods and Systems: Introduction to layered manufacturing, Importance of Additive Manufacturing, Additive Manufacturing in Product Development
Classification of additive manufacturing processes, Common additive manufacturing technologies; Fused Deposition Modeling (FDM), Selective Laser Sintering (SLS), Stereo Lithography (SLA), Selection Laser Melting (SLM), Digital Laser Processing (DLP), Jetting, 3D Printing, Laser Engineering Net Shaping (LENS), Laminated Object Manufacturing (LOM), Electron Beam Melting (EBM), Wire Arc Additive Manufacturing (WAAM), Electro Chemical AM, 4D Printing. Capabilities, materials, costs, advantages and limitations of different systems.


CAD in Additive Manufacturing: CAD Modelling for 3D printing: 3D Scanning and digitization, data handling & reduction Methods, AM Software: data formats and standardization, Slicing algorithms: uniform flat layer slicing, adaptive slicing, Process-path generation: Process-path algorithms, rasterisation, part Orientation and support generation.

Design for Additive Manufacturing: Design for minimum material usage, Topology design optimization, Mass customization, Generative Design, Part consolidation, Design guidelines for extrusion, liquid and powder-based AM.

**Laboratory:**
CAD Modeling: Introduction to CAD environment, Sketching, Modeling and Editing features, Different file formats, Export/Import geometries, Part orientation, Slicing, Support generation-FDM/SLA, Process path selection, Printing-FDM/SLA,

**Text Books/References:**

**Evaluation Pattern:**

<table>
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<td>End Semester</td>
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</table>

*Can be assignments, tutorials, quizzes, term paper, experiments, mini projects presentations, etc.,
Course Objectives:
1. Understand the concept and application for Design for manufacturing and assembly and its impact on product cost and quality.
2. Be able to optimize tolerances to enhance manufacturability.
3. Be able to optimize various manufacturing processes to enhance manufacturability.
4. Be able to discuss various fundamentals of assembly and design recommendations for product development.

Course Outcomes:

<table>
<thead>
<tr>
<th>CO</th>
<th>CO Description</th>
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</thead>
<tbody>
<tr>
<td>CO01</td>
<td>Understand the Design fundamentals, material selection process and compare the cost implications of the Design and manufacturability of various products.</td>
</tr>
<tr>
<td>CO02</td>
<td>Apply design guidelines for manufacturing processes like casting, welding, forming machining and powder metallurgy.</td>
</tr>
<tr>
<td>CO03</td>
<td>To Understand and Evaluate the Environmental impacts due to the DFMA process.</td>
</tr>
<tr>
<td>CO04</td>
<td>Analyze any product and Improve upon the existing ones using the DFMA guidelines and principles.</td>
</tr>
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CO-PO Mapping:

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</tbody>
</table>

Skills Acquired:

Develop designs by considering manufacturability, material selection for product design, tolerance analysis

Syllabus:

Group technology, Value engineering, development and evaluation of alternative solutions, Tolerance analysis Introduction to materials and material selection: Classification of engineering materials, Material selection for product design. Classification of the manufacturing process, Basic manufacturing processes, Mechanical properties of the material.

Design for Casting- Introduction to casting - Sand casting, Die-casting, Injection moulding - Design recommendation, suitable materials

Metal Extrusion: Introduction to Metal Extrusion Process – Metal stamping, Rolled formed section, Design for extrusion, Design for Forging - Suitable Material, Design Recommendations

Design for welding: Design for the recommendation for welding process, Design for solder and brazed assembly, Design for adhesively bonded constructions - Suitable materials, Design recommendations

Case studies on product design for manufacturing and assembly.

**Text Books/ References:**


**Evaluation Pattern:**

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<tr>
<td>End Semester</td>
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</tbody>
</table>

*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,*
Course Objectives:
1. To familiarize the metallurgical aspects of metal forming and its classification.
2. To give exposure to stress-strain effect and microstructural differences due to various forming processes.
3. To understand the various forces and geometrical relationship during rolling of metals.
4. To select and apply various sheet metal forming processes such as shearing, blanking, bending, stretch forming, deep drawing, drawing and extrusion.

Course Outcomes:

<table>
<thead>
<tr>
<th>CO</th>
<th>CO Description</th>
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</thead>
<tbody>
<tr>
<td>CO01</td>
<td>Understand the stress strain relations in elastic and plastic deformation, concept of flow stresses, deformation mechanisms and the metal forming effects on mechanical properties.</td>
</tr>
<tr>
<td>CO02</td>
<td>Analyze mechanics of metal working, flow stress determination, temperature in metal working and microstructural differences of various hot and cold working processes.</td>
</tr>
<tr>
<td>CO03</td>
<td>Perform suitable rolling processes and to analyze the rolling load, rolling variables, problems and defects in rolled products.</td>
</tr>
<tr>
<td>CO04</td>
<td>Examine the forming limit criteria, analysis of extrusion process and defects in formed parts and to understand the various sheet metal forming operations.</td>
</tr>
</tbody>
</table>

CO-PO Mapping:

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</table>

Skills Acquired:

Deformation mechanisms, identification of metallurgical changes during forming, select suitable technique to form the material into suitable shape and size, able to identify the reasons for defects during forming.

Syllabus:
Metallurgical aspects of metal forming-slip, twinning mechanics of plastic deformation-effects of temperature, strain rate, microstructure and friction in metal forming - yield criteria and their significance-classification of metal forming processes-advantages and limitations-stress strain relations in elastic and plastic deformation-concept of flow stresses-deformation mechanisms- hot and cold working processes and its effect on mechanical Properties.

Fundamentals of metal working: Classification of forming processes, mechanics of metal working, flow stress determination, temperature in metal working, strain-rate effects, metallurgical structure, friction and lubrication. Forging: Classification, forging in plane strain, calculation of forging loads, forging defects: incomplete die filling, die misalignment, laps, incomplete forging penetration, microstructural differences, hot shortness, pitted surface, surface cracking, micro cracking due to residual stresses
Rolling of metals: Classification, hot and cold rolling, forces and geometrical relationships, simplified analysis of rolling load, rolling variables, problems and defects in rolled products: centreline cracking, warping, edge wrinkling, edge cracking, centre splitting, centreline wrinkling- torque and power.

Extrusion: Classification, deformation, lubrication, defects, analysis of extrusion process.
Drawing of rods, wires and tubes: Introduction, analysis of wire and tube drawing, residual stresses.
Sheet metal forming: Introduction, forming methods, shearing, blanking, bending, stretch forming, deep drawing, forming limit criteria, defects in formed parts. Codes and Standards

Text Books/References:


Evaluation Pattern:

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*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,
Course Objectives:
1. Introduce the traditional and modern methods of optimization techniques used for solving non-linear unconstrained and constrained engineering optimization problems.
2. Considering the computational aspects, the course will involve a significant number of computational assignments using software tools and a term project in the area of engineering optimization.

Course Outcomes:

<table>
<thead>
<tr>
<th>COs</th>
<th>CO Description</th>
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<tbody>
<tr>
<td>CO01</td>
<td>Formulate the engineering problems as an optimization problem</td>
</tr>
<tr>
<td>CO02</td>
<td>Apply necessary and sufficient conditions for a given optimization problem for optimality</td>
</tr>
<tr>
<td>CO03</td>
<td>Select appropriate solution methods and strategies and solve optimization problems</td>
</tr>
<tr>
<td>CO04</td>
<td>Justify and apply the use of modern heuristic methods for solving complex optimization problems to obtain optimal / near-optimal solution</td>
</tr>
<tr>
<td>CO05</td>
<td>Interpret and analyze the solution obtained by optimization algorithms and improve their convergence and solution quality</td>
</tr>
<tr>
<td>CO06</td>
<td>Solve Engineering Design and Manufacturing related optimization problems using software tools.</td>
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CO-PO Mapping:

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Skills Acquired:

Formulate the engineering problems as an optimization problem; Select appropriate solution methods and strategies and solve optimization problems; Solving complex optimization problems using heuristic/ metaheuristic approach; Solve Engineering Design and Manufacturing related optimization problems using software tools.

Syllabus:


**Lab Practice:**
Implementing optimization algorithm using software tools / Programming for solving Engineering Design / Manufacturing related problems

- Checking the optimality of unconstrained and constrained optimization problems using the Hessian matrix.
- Solving Linear, Mixed Integer, Quadratic, Non-Linear Unconstrained, and Constrained optimization problems using direct and gradient-based algorithms.
- Implementing Modern methods of optimization namely GA, SA, and PSO for solving large scale linear and complex non-linear optimization problems.
- Statistical modeling and Parameter optimization.
- Multi-objective optimization using Evolutionary Multi-Objective Optimization algorithms.
- Case studies / Project / Presentation / Report writing: Optimal design of real-world engineering problems.

**Text Books / References:**

**Evaluation Pattern:**

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*Can be assignments, tutorials, quizzes, term paper, experiments, mini projects presentations, etc.,*
Course Objectives:

➢ To expose the components of product life cycle management.
➢ To develop structure and effectiveness of configuration management.
➢ To describe various types of project flows and role assignments.
➢ To understand the issues related to change management.
➢ To understand configuration of product and data management.

Course Outcomes:

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<th>CO Description</th>
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<tbody>
<tr>
<td>CO01</td>
<td>Identify components of PLM/PDM</td>
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<tr>
<td>CO02</td>
<td>Evaluate the structure of configuration management.</td>
</tr>
<tr>
<td>CO03</td>
<td>Create project work flows and assign roles.</td>
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<tr>
<td>CO04</td>
<td>Analyze issues in change management.</td>
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<tr>
<td>CO05</td>
<td>Develop product configurations and manage the data.</td>
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CO-PO mapping

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Skills Acquired:

Know about digitally connected enterprise and operational complexity, business process optimization

Syllabus:


model - use of order generator for variant creation-registering of variants in product register-case studies. Implementation issues and best practices.

Text Books/ References:

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*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,
Course Objectives:
1. To develop a new product addressing sustainability issues;
2. To conduct a life cycle assessment on a product;
3. To compare and evaluate alternative manufacturing processes

Course Outcomes:

<table>
<thead>
<tr>
<th>CO</th>
<th>CO Description</th>
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<tbody>
<tr>
<td>CO01</td>
<td>Knowledge with the ability to contemplate and address impact from decisions on industrial economics, ecology and societal aspects on a universal level</td>
</tr>
<tr>
<td>CO02</td>
<td>Apply and utilize the knowledge within new areas and analyse previous unknown problems, challenges, and plan and organize implementations of actions</td>
</tr>
<tr>
<td>CO03</td>
<td>Elaborate their knowledge in areas, like management, manufacturing technologies and methods, engineering, energy, and communication</td>
</tr>
<tr>
<td>CO04</td>
<td>Effective communication and influence on colleagues, suppliers and customers and contribute to shape the basic values for future manufacturing</td>
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CO-PO Mapping:

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Skills Acquired:
Assess and design the life cycle of products, analyze processes for achieving sustainability in manufacturing

Syllabus:
Introduction to the environmental issues pertaining to the manufacturing sector – pressure to reduce costs – processes that minimize negative environmental impacts – environmental legislation and energy costs – acceptable practice in society – adoption of low carbon technologies – need to reduce the carbon footprint of manufacturing operations.

Cost and income based approaches, demand estimation methods – expressed and revealed preference, choice modeling – Multi-criteria analysis- Stakeholder analysis – Environmental accounting at sector and national levels

Frameworks and techniques – environmental management systems – life cycle assessment – strategic and environmental impact assessments – carbon and water foot-printing

Challenges in logistics and supply chain – developing the right supply chain strategy for the products – need to align the supply network around the strategy – Tools that can be used systematically to identify areas for improvement in supply chains – Specific challenges and new thinking in the plan, source and delivering of sub-processes


Case Studies on sustainable manufacturing

**Text Books / References:**


**Evaluation Pattern:**

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*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,
Course Objectives:
1. To impart knowledge on the fundamentals of surface treatment and diffusion techniques.
2. To understand the working principle of Physical/chemical vapor deposition; plasma spray coating; plasma assisted ion implantation.
3. To illustrate various methods of surface modification like Micro Arc Oxidation/Plasma Electrolytic Oxidation process.
4. To understand the effects of phase transformation, post irradiation characterization and testing/evaluation of surface-properties.

Course Outcomes:

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<tr>
<td>CO01</td>
<td>To select suitable surface coating technique for a given requirement.</td>
</tr>
<tr>
<td>CO02</td>
<td>Select appropriate thermal process to alter the material surface</td>
</tr>
<tr>
<td>CO03</td>
<td>Apply the knowledge of tribology to improve wear resistance</td>
</tr>
<tr>
<td>CO04</td>
<td>To characterize the modified surface</td>
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CO-PO Mapping:

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Skills Acquired:

Understand various surfaces and its properties and ability to protect and modify the surfaces by applying various types of surface treatment and coatings. To learn characterization, novelty of composition and microstructure with the knowledge on testing and evaluation of surface properties.

Syllabus:
Introduction to surface engineering-Classification of surfaces and properties-Surface degradation, Wear and Corrosion - types of wear-Roles of friction and lubrication-Overview of different forms of corrosion-Surface treatment and coating: Chemical and Electrochemical polishing, Chemical conversion coatings, Phosphating, Chromating, Chemical colouring, Anodizing of aluminium alloys- Thermo chemical processes-Surface pre-treatment-Deposition of copper, zinc, nickel and chromium - principles and practices-Alloy plating, Electro composite plating, Electro less plating of copper, nickel phosphorous, nickel-boron, electro less composite plating, application areas- Physical/Chemical vapour deposition, Plasma spray coating; Plasma assisted ion implantation, Surface modification by directed energy beams like Ion, Electron and Laser beams, Energy transfer, Beam configuration and modes-Solid lubricants coating and Surface corrosion resistance-Micro arc oxidation/Plasma electrolytic oxidation process-Diffusion phenomenon and equation-Effects of phase transformation-Simulation of surface modification processes-Solutions for practical problems-Novelty of composition and microstructure-Post irradiation characterization and testing/evaluation of surface, Properties, Structure and Property Correlation-Failure mechanisms

ASTM Standards for Mechanical and Tribological Testing
Text Books/ References:


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*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,
Course Objectives:

1. Inculcate the knowledge to develop and use finite element programs to solve and analyze 1D and Multi-D problems using different finite element procedures.
2. Inculcate the knowledge to formulate Strong, Weak, Galerkins, and Matrix forms to formulate and solve linear and non-linear multi-physics problems using the method of weighted residuals.
3. Utilize commercial finite element packages to model, solve, and analyze multi-physics problems.

Course Outcomes:

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<td>Classify and develop different finite element procedures to solve simple 1D and 2D static problems like bars, beams, trusses, frames, etc.</td>
</tr>
<tr>
<td>CO2</td>
<td>Formulate basic and higher order elements with applicability to 1D and Multi-D coordinate systems</td>
</tr>
<tr>
<td>CO3</td>
<td>Formulate and solve static and dynamic/transient problems in Solid Mechanics and Heat Transfer using the Method of Weighted Residuals</td>
</tr>
<tr>
<td>CO4</td>
<td>Estimate finite element assembly procedure by constructing ID, IEN, LM arrays</td>
</tr>
<tr>
<td>CO5</td>
<td>Develop finite element models to solve and analyze, static and dynamic, linear and non-linear multi-physics problems using a finite element package</td>
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CO-PO Mapping:

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Skills Acquired:

Finite Element Modeling, Element Selection, Development of Process Model, Use finite element package to solve practical problems.

Syllabus:


Structural dynamics: Formulation - Element mass matrices - Evaluation of Eigen values and Eigen vectors - Natural frequencies and mode shapes - Numerical time integration.
Computer implementation of the Finite element method: pre-processing, element calculation, equation assembly, Solving, Post processing – primary and secondary variables. Introduction to computational packages.

Lab: Exercises covering structural analysis, dynamic analysis using and thermo mechanical coupled analysis FEA packages – Finite element modelling of metal forming and metal cutting operation

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*Can be assignments, tutorials, quizzes, term paper, experiments, mini projects presentations, etc.,
Course Objectives:
1. The course presents the theory of modeling with a variation using physical models and methods for practical applications on designs more insensitive to variation.
2. Provides a comprehensive understanding of optimization and robustness for probabilistic design

Course Outcomes:

<table>
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<tbody>
<tr>
<td>CO01</td>
<td>Familiarize with the statistical theories required for implementing robust design concepts in product development</td>
</tr>
<tr>
<td>CO02</td>
<td>Create designs that have minimal sensitivity to input variation</td>
</tr>
<tr>
<td>CO03</td>
<td>Perform sensitivity analysis and determine design parameters that have the largest impact on variation</td>
</tr>
<tr>
<td>CO04</td>
<td>Optimize design with multiple outputs</td>
</tr>
<tr>
<td>CO05</td>
<td>Create Empirical models to estimate system outputs</td>
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CO-PO Mapping:

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Skills Acquired:
Perform sensitivity analysis and determine design parameters that have the largest impact on variation; Conduct Tolerance Analysis; Develop Empirical models to estimate system outputs.

Syllabus:

Introduction to variation in Engineering Design: Propagation of error, protecting design against variations, Estimation of statistical parameters, statistical bias, robustness, determining the variation of inputs using simulation approach - Modelling variation of complex systems – Desirability: Requirements and scorecards, determining desirability.

Empirical Modelling: Screening, Response Surfaces, Central Composite Design, Taguchi approach – Logistic regression and customer loss function – Case studies - Engineering model verification and validation:
Introduction, Design verification methods, and tools, Process validation procedure, Case study and Problem-solving using software tools.

Text Books/ References:

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*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,
Course Objectives:
1. To develop an understanding of how the operations, have strategic importance and can provide a competitive advantage in the workplace
2. To anticipate issues in production and operations processes, practitioners may face during their careers
3. To apply operations management concepts and their influence on business decisions.

Course Outcomes:

<table>
<thead>
<tr>
<th>CO</th>
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<tbody>
<tr>
<td>CO01</td>
<td>To understand the principles and applications relevant to the planning, design and operations of manufacturing/service firms.</td>
</tr>
<tr>
<td>CO02</td>
<td>To identify production planning and control strategies for a balanced system capacity and inventory.</td>
</tr>
<tr>
<td>CO03</td>
<td>To apply qualitative methods and analytical tools to assist in decision making on operational issues.</td>
</tr>
<tr>
<td>CO04</td>
<td>To analyze and create forecasting and operation scheduling systems.</td>
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Skills Acquired:

Understand various concepts and issues in production and operations. Better application of production planning strategies. Ability to select suitable inventory models. To select suitable production scheduling technique.

Syllabus:

Text Books/ References:


Evaluation Pattern:

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*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,
Course Objectives:

➢ To expose the complexities and key issues in supply chain management.
➢ To develop location models, logistics networks, traveling salesman and vehicle routing and scheduling models.
➢ To analyze the inventory models, strategic alliances, role of information and integration in supply chain.
➢ To understand the issues related to global supply chains, procurement and outsourcing, product chain design and customer value.
➢ To understand advanced topics in supply chain related to Industry 4.0 and sustainability.

Course Outcomes:

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<tbody>
<tr>
<td>CO01</td>
<td>Analyze the complexity and key issues in supply chain management</td>
</tr>
<tr>
<td>CO02</td>
<td>Evaluate single and multiple facility location problems, logistics network configuration, vehicle routing and scheduling models.</td>
</tr>
<tr>
<td>CO03</td>
<td>Analyze inventory models, dynamics of supply chain and role of information in supply chain.</td>
</tr>
<tr>
<td>CO04</td>
<td>Develop the appropriate supply chain through strategic alliances and supply chain integration.</td>
</tr>
<tr>
<td>CO05</td>
<td>Identify the issues in global supply chains, procurement, outsourcing, product chain design and customer value.</td>
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<tr>
<td>CO06</td>
<td>Develop models in Logistics 4.0, digital supply chains, sustainable supply chains, urban logistics and humanitarian logistics.</td>
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CO-PO mapping:

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Skills Acquired:

Analyze key issues in supply chain management and develop models and solutions

Syllabus:
Introduction: Introduction to SCM—the complexity and key issues in SCM. Location strategy—facility location decisions—single facility and multiple location models. Inventory strategy: Inventory Management and risk pooling—managing inventory in the SC.


Text Books/References:

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*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,
Course Objective:

Provide the importance of reliability, the basic methods to evaluate product and system reliability

Course Outcomes:

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<tr>
<td>CO01</td>
<td>Determine the reliability of a product by applying the knowledge of probabilistic concept.</td>
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<tr>
<td>CO02</td>
<td>Identify and select the various failure models</td>
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<tr>
<td>CO03</td>
<td>Identify and select different reliability testing methods</td>
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<tr>
<td>CO04</td>
<td>Predict the reliability of a product using failure data.</td>
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CO-PO Mapping:

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Skills Acquired:

Ability to determine reliability of a system and to identify suitable testing methods for industrial applications

Syllabus:


Approaches to intelligent control- AI approach- Concept of artificial neural network and its model, fuzzy logic and its model- Case study

Text Books/ References:

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*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,
Course Objectives:
1. Exposure to modern quality philosophies and advanced quality engineering techniques
2. To manage quality in research, design and delivery of engineering works and investigation, as well as of safe work practices and systems assurance.
3. Prepare students to take positions such as lead quality engineer or engineering technologist with a possible role in management

Course Outcomes:

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<tbody>
<tr>
<td>CO01</td>
<td>Understand and apply the concepts in quality engineering to achieve organizational excellence.</td>
</tr>
<tr>
<td>CO02</td>
<td>Process evaluation and control by various statistical methods and quality standards</td>
</tr>
<tr>
<td>CO03</td>
<td>Implementation of different quality models for effective costs of quality systems.</td>
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<tr>
<td>CO04</td>
<td>Learn about quality and reliability perspectives of manufacturing systems</td>
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CO-PO Mapping:

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Skills Acquired:
Conduct of Process Capability Studies, Interpret Data, Implementation of TQM concepts in an Industry

Syllabus:

Process evaluation and control by designs of experiment: Various basic designs; Special methods such as EVOP and ROBUST design (Taguchi Methods). Six Sigma Management: Concepts, Steps and Tools; Benchmarking and Balanced Score Cards. TPM, FMECA, Fault Tree Analysis, Quality and reliability perspectives of JIT. Training for Quality. Application of Software tools and Case Studies.

Text Book/ References:

**Evaluation Pattern:**

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*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,*
Course Objectives:
1. To introduce students to a variety of case studies associated with Non-destructive testing methods and designed to provide a sound theoretical knowledge on inspection, evaluation, Testing and Documenting.

2. To provide knowledge about the conventional and advanced NDT tools by enhancing the experience for inspecting and evaluating components in accordance with industry specifications.

3. To develop a fundamental knowledge about the calibration, advanced techniques and the recent developments in non-destructive testing so as to improve the quality in manufacturing engineering components.

Course Outcomes:

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<tr>
<td>CO01</td>
<td>Analyze the various metallurgical factors influencing the performance of materials and manufacturing processes for examine the defects for different engineering applications.</td>
</tr>
<tr>
<td>CO02</td>
<td>Understanding on different NDE techniques and apply them for inspecting materials with industrial standards along with case studies.</td>
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<tr>
<td>CO03</td>
<td>Select proper advanced NDE technique and compare the best technique for specific applications by applying all NDT methods by understanding the recent developments for various applications.</td>
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<tr>
<td>CO04</td>
<td>Calibrating the instrument and the knowledge on NDT tools which enables them to perform inspection and document on component for imperfections as per standard and follow proper safety precautions.</td>
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CO-PO Mapping:

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Skills Acquired:

Create, select, learn and apply appropriate techniques in NDT and to predict defects in various engineering components and structures

Syllabus:


Text Books/References:

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*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,
Course Objectives:
1. Equip students with the knowledge metallic and non-metallic (metal-alloy-composites Vs amorphous)
2. Enhance the students with knowledge of manufacturing processes
3. Equip the students to solve the new material design and process design for composite material
4. To demonstrate the design and development of futuristic and advanced composite materials and processes
5. To demonstrate composite for real time applications

Course Outcomes:

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<tbody>
<tr>
<td>CO01</td>
<td>Select suitable composite materials for various conventional and advanced applications</td>
</tr>
<tr>
<td>CO02</td>
<td>Master in selecting the appropriate manufacturing processes of the composite materials</td>
</tr>
<tr>
<td>CO03</td>
<td>Analyse the processes behaviour and equipment design for advanced composites</td>
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<tr>
<td>CO04</td>
<td>Evaluate and identity composite product for real time application (case study )</td>
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<tr>
<td>CO05</td>
<td>Create new materials, design and methods for advanced composite material</td>
</tr>
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</table>

Skills Acquired:

Composite material selection and processes composite for day to life (real life applications) Composite design (material science) and material development

Syllabus:


Testing and inspection methods for composites: Experimental techniques, compositional Introduction to advanced instrumental characterization and introduction to advanced characterization techniques (XRD, XRF, ITFR, SEM, TEM, TGA etc). Non-Destructive Analyses of Composites. Special case study: composites from day to day life to aerospace

Text Books/ References:

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*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,
Course Objectives:
1. Analyze the forces involved in cutting to design cutting tools.
2. Describe the principles of location and clamping to design jigs and fixtures for a given component.
3. Describe the machines involved, force calculations to design press tools for a given component.

Course Outcomes:

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<tr>
<td>CO01</td>
<td>Design cutting tools considering cutting forces, strength and rigidity.</td>
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<tr>
<td>CO02</td>
<td>Design and development of jigs for a given component.</td>
</tr>
<tr>
<td>CO03</td>
<td>Design and development of fixtures for a given component.</td>
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<tr>
<td>CO04</td>
<td>Design and development of press tools for a given component.</td>
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CO-PO mapping:

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Skills Acquired:
Design cutting tools, jigs, fixtures and press tools for any given component

Syllabus:

bending, drawing and forming dies- blank development, strain factor, calculation of force, construction of drawing and drawing dies.

**Text Books/ References:**

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*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,
Course Objectives:

1. To learn new material on processing, characteristics and applications
2. To explore joining techniques for space and nuclear applications

Course Outcomes (COs):

<table>
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<tbody>
<tr>
<td>CO01</td>
<td>Gain knowledge about thermodynamics of interfaces and various interface</td>
</tr>
<tr>
<td>CO02</td>
<td>Master the different modes of nucleation and its kinetics</td>
</tr>
<tr>
<td>CO03</td>
<td>Apply the diffusion equation for simple and practical problems</td>
</tr>
<tr>
<td>CO04</td>
<td>Select the appropriate strengthening method for alloys</td>
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<tr>
<td>CO05</td>
<td>Acquire advanced knowledge about different material characterization techniques</td>
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CO-PO Mapping

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Skills Acquired:

About the materials and manufacturing process for aerospace and nuclear field Identification of new or futuristic requirement, design of materials for the same by metallurgical approach

Syllabus:

Detailed study and equipment design for advanced and high tech material processing: Introduction, definition and classification of different types of Engineering Materials for aerospace, space, nuclear and defence applications (such as: Titanium alloys, super alloys, aluminium & light alloys, composites, tungsten-tantalum alloys, Moly and PM)

Elaborate study on properties, Composition and processing techniques of advanced materials, Layout of advanced processing techniques, classification, application and importance, Additive manufacturing, 3D metal printing, laser and electron beam processing, vacuum induction, electro-slag, vacuum arc, and controlled atmosphere processing.

Joining technologies for space and aerospace: EBW, Diffusion bonding, vacuum brazing, friction based joining techniques, atmosphere controlled joining of aero engine components, heavy alloy powder processing, functionally gradient materials

Aero-structures and nuclear power plant structural study, design of material for the same.
Text Book/ References:


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*Can be assignments, tutorials, quizzes, term paper, experiments, presentations, etc.,
Course Objectives:
1. Introduce the classical and evolutionary methods of optimization techniques used for solving engineering optimization problems with multiple objectives.
2. Considering the computational aspects, the course will involve a significant number of computational assignments using software tools and a term project focusing on solving multi-objective optimization problems in design and manufacturing fields.

Course Outcomes:

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<th>CO Description</th>
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<tbody>
<tr>
<td>CO01</td>
<td>Formulate Engineering problem as a multi-objective optimization problem</td>
</tr>
<tr>
<td>CO02</td>
<td>Apply evolutionary optimization techniques to solve complex Engineering problems involving multiple objectives using classical optimization approaches</td>
</tr>
<tr>
<td>CO03</td>
<td>Appreciate the concepts of Pareto optimality and generate non-dominated solutions using evolutionary algorithms for solving multi-objective optimization problems</td>
</tr>
<tr>
<td>CO04</td>
<td>Formulate and solve real-world MOOPs in Engineering Design / Manufacturing fields using Evolutionary Multi-Objective approaches and generate non-dominant solutions using software tools</td>
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CO-PO Mapping:

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<tr>
<th>COs</th>
<th>PO1</th>
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<th>PO4</th>
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Skills Acquired:

Formulate Engineering problem as a multi-objective optimization problem; Solve multi objective optimization problems using traditional and evolutionary muti- objective optimization algorithm; Generate solutions for muti-objective optimization problems using software tools.

Syllabus:

Problem Formulation: System characterization - Identification of objectives, design variables, constraints, subsystems - System-level coupling and interactions - Examples of Multi-Objective Optimization (MOO) Problems in practice - Visualization techniques in design optimization.


Lab Practice:
• Solving multi-objective optimization problems using classical optimization approach (Goal programming / Weighted sum approach)
• Solving multi-objective optimization problems using evolutionary methods (NSGA-II / PSO based approach)
• Applications of Multi-Objective Evolutionary algorithms: Case Study - Mechanical Component Design – Shape, topology, and trajectory optimization – Implementation of MOO algorithms to solve real-world applications using software tools.

Text Books/ References:

Evaluation Pattern:

<table>
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<tr>
<th>Evaluation Components</th>
<th>Internal</th>
<th>External</th>
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<td>Continuous Assessment (Lab)*</td>
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*Can be assignments, tutorials, quizzes, term paper, experiments, mini projects presentations, etc.,