# List of Open Electives Offered By the Department of Mechanical Engineering

## Open Elective I (Interdisciplinary) (III Year – I Semester)

| Branch | Subject Code | Subject Name |
|---|---|---|
| ME | 23AME55A | Sustainable Energy Technologies |
| ME | 23AME55B | Supply Chain Management |
| ME | 23AME55C | Nanotechnology |
| ME | 23AME55D | Industry 4.0 |
| ME | 23AME55E | Entrepreneurship |

## Open Elective II (Interdisciplinary) (III Year – II Semester)

| Branch | Subject Code | Subject Name |
|---|---|---|
| ME | 23AME65A | Introduction to Industrial Robotics |
| ME | 23AME65B | Work Study and Industrial Ergonomics |
| ME | 23AME65C | Customer Relationship Management |
| ME | 23AME65D | Hybrid Vehicles |
| ME | 23AME65E | Industrial Safety |

## Open Elective III (Interdisciplinary) (IV Year – I Semester)

| Branch | Subject Code | Subject Name |
|---|---|---|
| ME | 23AME74A | 3D Printing Technologies |
| ME | 23AME74B | Introduction to Mechatronics |
| ME | 23AME74C | Robot Programming |
| ME | 23AME74D | Product Design and Development |
| ME | 23AME74E | Digital Marketing Management |

## Open Elective IV (Interdisciplinary) (IV Year – II Semester)

| Branch | Subject Code | Subject Name |
|---|---|---|
| ME | 23AME75A | Total Quality Management |
| ME | 23AME75B | Optimization Techniques |
| ME | 23AME75C | Advanced Manufacturing Systems |
| ME | 23AME75D | Operations Management |
| ME | 23AME75E | Energy Auditing |

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**B.Tech III Year I Semester**

**23AME55A – SUSTAINABLE ENERGY TECHNOLOGIES**

**{OPEN ELECTIVE-I (A)}**

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**Course Objectives:** The objectives of the course are to make the students learn about

- To demonstrate the importance and solar radiation, solar energy collection and storage.
- To understand the energy sources and potential from wind energy, bio-mass, geothermal energy and ocean energy.
- To interpret energy efficient electrical and mechanical systems.
- To develop energy efficient processes.
- To understand features and benefits of green buildings.

**Course Outcomes:** At the end of the course, the students will be able to

**CO1**: Understand the fundamentals of solar radiation, sun-earth geometry, and evaluate solar radiation incident on different surfaces.

**CO2**: Analyze the design, construction, performance, and installation of solar photovoltaic (PV) modules and systems.

**CO3**: Comprehend different energy storage technologies and assess battery systems in solar PV applications.

**CO4**: Explore the principles of solar energy collection, storage, and various thermal solar applications.

**CO5**: Examine the potential and working principles of wind, biomass, geothermal, tidal, and ocean energy systems.

**UNIT – I:** **12 Hrs**

**.SOLAR RADIATION**: Role and potential of new and renewable sources, the solar energy option, Environmental impact of solar power, structure of the sun, the solar constant, sun-earth relationships, coordinate systems and coordinates of the sun, extraterrestrial and terrestrial solar radiation, solar radiation on titled surface, instruments for measuring solar radiation and sun shine, solar radiation data, numerical problems.

**SOLAR PV MODULES AND PV SYSTEMS:**

PV Module Circuit Design, Module Structure, Packing Density, Interconnections, Mismatch and Temperature Effects, Electrical and Mechanical Insulation, Lifetime of PV Modules, Degradation and Failure, PV Module Parameters, Efficiency of PV Module, Solar PV Systems-Design of Off Grid Solar Power Plant. Installation and Maintenance.

**UNIT – II:** **10Hrs**

**STORAGE IN PV SYSTEMS:**

Battery Operation, Types of Batteries, Battery Parameters, Application and Selection of Batteries for Solar PV System, Battery Maintenance and Measurements, Battery Installation for PV System.

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| **UNIT – III:** | **8 Hrs** |
|---|---|
| **SOLAR ENERGY COLLECTION**: Flat plate and concentrating collectors, classification of concentrating collectors, orientation.<br><br>**SOLAR ENERGY STORAGE AND APPLICATIONS**: Different methods, sensible, latent heat and stratified storage, solar ponds, solar applications- solar heating/cooling technique, solar distillation and drying, solar cookers, central power tower concept and solar chimney. | |
| **UNIT – IV:** | **8Hrs** |
| **WIND ENERGY**: Sources and potentials, horizontal and vertical axis windmills, performance characteristics, betz criteria, types of winds, wind data measurement.<br><br>**BIO-MASS**: Principles of bio-conversion, anaerobic/aerobic digestion, types of bio-gas digesters, gas yield, utilization for cooking, bio fuels, I.C. engine operation and economic aspects. | |
| **UNIT – V:** | **8Hrs** |
| **GEOTHERMAL ENERGY**: Resources, types of wells, methods of harnessing the energy.<br><br>**OCEAN ENERGY**: OTEC, Principles of utilization, setting of OTEC plants, thermodynamic cycles. Tidal and wave energy: Potential and conversion techniques. | |

**Text Books:**


1. S.P.Sukhatme and J.K. Nayak, Solar Energy – Principles of Thermal Collection and Storage, 3/e, Tata McGraw Hill, 2008.
2. B.H.Khan, Non- Conventional Energy Recourses, 2/e, Tata McGraw Hill, 2006.
3. J. Paulo Davim, Green Manufacturing Processes and Systems, 1/e, Springer, 2013.


**Reference Books:**


1. K.S. Jagadeesh, B.V. Venkata Rama Reddy, and K.S. Nanjunda Rao, Alternative Building Materials and Technology, 1/e, New Age International, 2005.
2. D. Yogi Goswami, Frank Kreith, and John F. Kreider, Principles of Solar Engineering, 2/e, Taylor & Francis, 2000.
3. Ashok V. Desai, Non-Conventional Energy, 1/e, New Age International, 2003.
4. Ramesh and K. Kumar, Renewable Energy Technology, 1/e, Narosa Publishing House, 2004.
5. G.D. Rai, Non-Conventional Energy Sourses, 5/e, Standared Publisjers, 2011.
6. J. Twidell and T. Weir, Renewable Energy Resources, 2/e, BSP Books Pvt,. Ltd., 2006.
7. Gregor Hoogers, Fuel Cell Technology Handbook, 1/e, BSP Books Pvt,. Ltd., 2003
8. Martin A. Green, Solar Cells: Operating Principles, Technology and system Applications, 1/e, University of New South Wales, 1998.


**Online Learning Resources:**

- https://nptel.ac.in/courses/121105010
- https://youtu.be/6nE5mJhYJ3o
- https://nptel.ac.in/courses/112104189
- https://youtu.be/n4E1rHLyq2s
- https://nptel.ac.in/courses/112107292

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**JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA**

**B.Tech III Year I Semester**

**23AME55B – SUPPLY CHAIN AND MANAGEMENT**

**{OPEN ELECTIVE-I (B)}**

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**Course Objectives:** The objectives of the course are to make the students learn about

- Explain the basics of supply chain management.
- Familiarize inventory management techniques and models to ensure EOQ batch size under risk management.
- Demonstrate various distribution strategies for shipment of products.
- Focus on evaluating of strategic alliance partners and understanding of RDBMS
- Know about Third party Logistics (3PL)

**Course Outcomes:** At the end of the course, the students will be able to

**CO1:** Apply the concepts of supply chain management for demand forecasting.

**CO2:** Make use of SCM and inventory management for procurement

**CO3:** Analyse the shipment activities and related issues

**CO4:** Build third party alliances.

**CO5:** Adapt the RDBMS data for communications and analyzing future challenges and understand e-commerce strategies

**UNIT – I:** **8 Hrs**

**Understanding the supply chain:** What is SCM? Why SCM? The Complexity, Key issues in SCM Logistics network - Introduction, Data Collection, Transportation, Ware house Management, Strategic location of ware houses, Demand forecasting, Role of aggregate planning, MRP, ERP, Managing variability, Key features of Network configuration.

**UNIT – II:** **8 Hrs**

**Inventory management:** Inventory management: Concepts of Materials Management, Economic lot size model, Effect of Demand uncertainly, Fixed order costs, Variable lead frames, Inventory under certainly & uncertainty, Risk Management.

**UNIT – III:** **8 Hrs**

**Distribution strategies:** Distribution strategies: Introduction, Centralized vs Decentralized control, Direct shipment, Cross Docking, Push based vs Pull based supply chain.

**UNIT – IV:** **8Hrs**

**Strategic alliances:** Third party Logistics (3PL), Retailer – supplier relationship issues, requirements, success & failures, Distributor integration Types & issues.

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| UNIT – V: | 10 Hrs |
|---|---|
| **MIS & SCM**: Relational Data Base Management (RDBMS), System Architecture, Communications, and Implementation of ERP, Decision support systems for SCM: Analytical tools, Presentation tools, Smooth production flow Current issues & directing challenges for future, e-Commerce strategies and world class supply chain management. | |
| **Text Books:** | |
| 1. Sunil Chopra, Peter Meindl, Supply Chain Management: Strategy, Planning, and Operation, 4/e, Pearson, 2010. | |
| 2. David N. Burt, Donald W. Dobler , World Class Supply Management: The Key to Supply Chain Management, 2/e, McGraw-Hill/Irwin, 2003. | |
| **Reference Books:** | |
| 1. John Joseph Coyle, Edward J. Bardi, C. John Langley, The Management of Business Logistics: A Supply Chain Perspective, South-Western/Thomson Learning, 2003. | |
| 2. Upendra Kachru ,Logistics and Supply Chain Management, Excel Books, 2009. | |
| **Online Learning Resources:** | |
| • https://nptel.ac.in/courses/110105083 | |
| • https://ocw.mit.edu/courses/15-763j-manufacturing-system-and-supply-chain-design-spring-2005/ | |
| • https://youtu.be/ZkRcSENr_0s | |
| • https://www.coursera.org/specializations/supply-chain-management | |
| • https://www.scmglobe.com/ | |

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**B.Tech III Year I Semester**

**23AME55C – NANO TECHNOLOGY**

**{OPEN ELECTIVE-I (C)}**

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**Course Objectives:** The objectives of the course are to make the students learn about

- To understand the classification of Nano structured Materials.
- To understand the unique properties of Nano materials.
- To interpret the Synthesis Routes - Bottom up and Top down approaches.
- To identify the tools to characterize Nano materials.
- To understand the applications of Nano materials.

**Course Outcomes:** At the end of the course, the students will be able to

**CO1:** Understand the classification of nanostructured Materials

**CO2:** Understand the unique properties of nano materials

**CO3:** Interpret the Synthesis Routes - Bottom up and Top down approaches

**CO4:** Identify the tools to characterize nano materials

**CO5:** Understand the applications of nano materials

**UNIT – I:** **8 Hrs**

. **INTRODUCTION**: History and Scope, Classification of Nano structured Materials, Fascinating Nanostructures, and applications of nano-materials, challenges and future prospects.

**UNIT – II:** **10 Hrs**

**UNIQUE PROPERTIES OF NANO MATERIALS:** Microstructure and Defects in Nano crystalline Materials: Dislocations, Twins, stacking faults and voids, Grain Boundaries, triple and disclinations. Effect of Nano-dimensions on Materials Behavior: Elastic properties, Melting Point, Diffusivity, Grain growth characteristics, enhanced solid solubility. Magnetic Properties: Soft magnetic nanocrystalline alloy, Permanent magnetic nanocrystalline materials, Giant Magnetic Resonance, Electrical Properties, Optical Properties, Thermal Properties and Mechanical Properties.

**UNIT – III:** **8 Hrs**

**SYNTHESIS ROUTES**: Bottom up approaches: Physical Vapor Deposition, Inert Gas Condensation, Laser Ablation,Chemical Vapor Deposition, Molecular Beam Epitaxy, Sol-gel method, Self-assembly. Top down approaches: Mechanical alloying, Nano-lithography.Consolidation of Nano powders: Shock wave consolidation, Hot iso-static pressing and Cold iso-static pressingSpark plasma sintering.

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| UNIT – IV: | 8Hrs |
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| **TOOLS TO CHARACTERIZE NANOMATERIALS**: X-Ray Diffraction (XRD), Small Angle X-ray scattering, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Scanning Tunneling Microscope (STM), Field Ion Microscope (FEM), Three-dimensional Atom Probe (3DAP), Nano indentation - scratch hardness test. | |
| **UNIT – V:** | **8Hrs** |
| **APPLICATIONS OF NANO MATERIALS**: Nano-electronics, Micro- and Nano-electromechanical systems (MEMS/NEMS), Nano sensors, Nano catalysts, Food and Agricultural Industry, Cosmetic and Consumer Goods, Structure and Engineering, Automotive Industry, Water- Treatment and the environment, Nano-medical applications, Textiles, Paints, Tiles, Energy, Defense and Space Applications, Concerns and challenges of Nanotechnology. | |
| **Text Books:** | |
| 1. Charles P. Poole Jr. and Frank J. Owens, Introduction to Nanotechnology, 1/e, Wiley India Pvt. Ltd., 2003. | |
| 2. A.K. Bandyopadhyay, Nano Materials, 1/e, New Age International Publishers, 2007. | |
| 3. T. Pradeep, Nano: The Essentials, 1/e, Tata McGraw Hill, 2007. | |
| **Reference Books:** | |
| 1. S.O. Pillai, Solid State Physics, 5/e, New Age International (formerly Wiley Eastern Ltd.), 2005. | |
| 2. Charles Kittel, Introduction to Solid State Physics, 7/e, John Wiley & Sons (Asia) Pvt. Ltd., 1996. | |
| **Online Learning Resources:** | |
| • https://nptel.ac.in/courses/118107017 | |
| • https://www.coursera.org/learn/nanotechnology | |
| • https://ocw.mit.edu/courses/2-62j-fundamentals-of-nanomechanics-fall-2004/ | |
| • https://link.springer.com/search?query=nanotechnology&facet-content-type=%22Book%22&showAll=false | |
| • https://nanohub.org | |

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**JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA**

**B.Tech III Year I Semester**

**23AME55D – INDUSTRY 4.0**

**{OPEN ELECTIVE-I (D)}**

| L | T | P | C |
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**Course Objectives:** The objectives of the course are to make the students learn about

- To apply knowledge of smart manufacturing systems' components in the context of Industry 4.0.
- To understand the concepts of smart machines and smart sensors .
- To understand and apply the concepts of IoT connectivity to Industry 4.0.
- To understand the concepts of Digital Twin and apply Machine Learning and Artificial Intelligence concepts in Manufacturing.
- To understand the concepts of Metaverse platform.

**Course Outcomes:**At the end of the course, the students will be able to

**CO1:** Learn about smart manufacturing systems' components and can handle it more effectively in context of Industry 4.0

**CO2:** Learn about the smart machines and smart sensors

**CO3:** Apply IoT to Industry 4.0 and they are able to make a system tailor-made as per requirement of the industry

**CO4:** Learn about concepts of Digital Twin and able to apply Machine Learning and Artificial Intelligence concepts in Manufacturing

**CO5:** Learn the concepts of AR/VR and Metaverse platform

**UNIT – I:** **8 Hrs**

**Concepts of Smart Manufacturing:** Definition and key characteristics of smart manufacturing, Corporate adaptation processes, manufacturing challenges, challenges vs technologies, Stages in smart manufacturing. Minimizing Six big losses in manufacturing with Industry 4.0, and their benefits.

**UNIT – II:** **10Hrs**

**Smart Machines and Smart Sensors:** Concept andFunctions of a Smart, Machine Salient features and Critical Subsystems of a Smart Machine, Smart sensors; smart sensors ecosystem, need, benefits and applications of sensors in industry, Introduction to IoT, IIoT, and Cyber physical systems, Sensing for Manufacturing Process in IIoT, Block Diagram of an IoT Sensing Device, Sensors in IIoT Applications, Smart Machine Interfaces,

**UNIT – III:** **8 Hrs**

**IoT connectivity for Industry 4.0:** Industrial communication requirement and its infrastructure, an overview of different types of networks, mesh network in industrial IoT, IoT protocols and the internet, TCP/IP (transmission control protocol/internet protocol) model, IoT connectivity standards: common protocols, application layer protocols, internet/network layer protocols, physical layer IoT protocols, choosing the right IoT connectivity protocol.

**UNIT – IV:** **8Hrs**

**Digital Twin:** Introduction, applications of digital twins, impact zones of digital twins in manufacturing (factories/plants and OEMs), advantages of digital twins, basic steps of digital twin technology

**Machine Learning (ML) and Artificial Intelligence (AI) in Manufacturing**: Introduction, benefits and applications of ML in industries, common approaches of ML; supervised and unsupervised, semi-supervised and reinforced ML.

**UNIT – V:** **8Hrs**

**Metaverse** – Basic concepts, AR/VR, Social Metaverse, Industrial Metaverse, How Web 3.0 is changing the Internet, Asset Classes Inside the Metaverse, Land, Coins, Characters/ Avatars, Skins, Utility, Industries Disrupted by the Metaverse, Smart wearables,

**Text Books:**


1. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 2/e, Pearson Education, 2010.
2. Tom M. Mitchell, Machine Learning, 1/e, McGraw Hill, 2013.
3. Ethem Alpaydin, Introduction to Machine Learning (Adaptive Computation and Machine Learning), 1/e, MIT Press, 2004.
4. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, 1/e, O'Reilly Media, 2017.
5. Vinod Chandra S.S. and Anand Hareendran S., Artificial Intelligence and Machine Learning: Principles and Applications, 1/e, PHI Learning, 2014.


**Reference Books:**


1. Elaine Rich, Kevin Knight, and Shivashankar B. Nair, Artificial Intelligence, 3/e, McGraw Hill Education, 2008.
2. Dan W. Patterson, Introduction to Artificial Intelligence and Expert Systems, 1/e, PHI Learning, 2012.
3. Vinod Chandra S.S. and Anand Hareendran S., Machine Learning: A Practitioner's Approach, 1/e, PHI Learning, 2018.
4. M.C. Trivedi, A Classical Approach to Artificial Intelligence, 1/e, Khanna Publishing House, New Delhi, 2018.
5. S. Kaushik, Artificial Intelligence, 1/e, Cengage Learning India, 2011.


**Online Learning Resources:**

- https://nptel.ac.in/courses/112105312
- https://www.mckinsey.com/business-functions/operations/our-insights/manufacturings-next-act
- https://nptel.ac.in/courses/108105062
- https://nptel.ac.in/courses/112105289
- https://youtu.be/6vZzG-LyJwo

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**JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA**

**B.Tech III Year I Semester**

**23AME55E -- ENTREPRENEURSHIP**

**{OPEN ELECTIVE-I (E)}**

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**Course Objectives:** The objectives of the course are to make the students learn about

- To understand the basic development of entrepreneurship as a profession.
- To understand business models.
- To write a business plan describing a new business venture.
- To understand marketing strategies for small businesses.
- To identify capital resources for new ventures and small businesses.

**Course Outcomes:** At the end of the course, the students will be able to

**CO1:** Understand the basic development of entrepreneurship as a profession.

**CO2:** Write a business plan describing a new business venture.

**CO3:** Identify capital resources for new ventures and small businesses.

**CO4:** Identify the issues related to Selection of layout.

**CO5:** Selection of production techniques.

**UNIT – I:** **8 Hrs**

Introduction to Entrepreneurship Definition of Entrepreneur, Entrepreneurial Traits, Entrepreneur vs. Manager, Entrepreneur vs Intrapreneur. The Entrepreneurial decision process. Role of Entrepreneurship in Economic Development, Ethics and Social responsibility of Entrepreneurs. Opportunities for Entrepreneurs in India and abroad. Woman as Entrepreneur.

**UNIT – II:** **10Hrs**

Creating and Starting the Venture, Sources of new Ideas, Methods of generating ideas, creating problem solving, product planning and development process.

The Business Plan Nature and scope of Business plan, Writing Business Plan, Evaluating Business plans, Using and implementing business plans. Marketing plan, financial plan and the organizational plan, Launching formalities.

**UNIT – III:** **8 Hrs**

Financing and Managing the new venture, Sources of capital, venture capital , angel investment, Record keeping, recruitment, motivating and leading teams, financial controls. Marketing and sales controls. E-commerce and Entrepreneurship, Internet advertising.

New venture Expansion Strategies and Issues, Features and evaluation of joint ventures, acquisitions, merges, franchising. Public issues, rights issues, bonus issues and stock splits

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|---|---|
| **UNIT – IV:** | **8Hrs** |
| Choosing location and layout, Issues related to Selection of layout. Global aspects of Entrepreneurship. | |
| **UNIT – V:** | **8Hrs** |
| Production and Marketing Management Thrust of production management, Selection of production Techniques, plant utilization and maintenance, Designing the work place, Inventory control, material handling and quality control.<br><br>Marketing functions, market segmentation, market research and channels of distribution, Sales promotion and product pricing. | |
| **Text Books:** | |
| 1. Entrepreneurship, Robert Hisrich, & Michael Peters, TMH, 5/e. | |
| 2. Entrepreneurship, Dollinger, Pearson, 4/e 2004. | |
| **Reference Books:** | |
| 1. Dynamics of Entrepreneurial Development and management, Vasant Desai, Himalaya Publishing House, 2004. | |
| 2. Harvard Business Review on Entrepreneurship. HBR Paper Back, 1999. | |
| 3. Entrepreneurial Management, . Robert J.Calvin:, TMH, 2004. | |
| 4. The Entrepreneurial Connection, Gurmeet Naroola TMH, 2001. 5. Indian Economy. Dutt&Sundaram S. Chand, 2005. | |
| 5. Essential of Entrepreneurship and small business management, Thomas W. Zimmerer& Norman M. Scarborough, PHI, 4/e, 2005. | |
| 6. Industrial Relations &Labour Laws, Srivastava, Vikas, 2005. | |
| 7. Industrial Law, ND Kapoor, Sultan Chand & Sons, 2005. | |
| **Online Learning Resources:** | |
| • https://nptel.ac.in/courses/110105139 | |
| • https://nptel.ac.in/courses/110107094 | |
| • https://youtu.be/4gJPllc4nUQ | |
| • https://nptel.ac.in/courses/110107094 | |
| • https://nptel.ac.in/courses/110107141 | |

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**JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA**

**B.Tech III Year II Semester**

**23AME65A – INTRODUCTION TO INDUSTRIAL ROBOTICS**

**(OPEN ELECTIVE – II (A))**

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**Course Objectives:** The objectives of the course are to make the students learn about

- Discuss various applications and components of industrial robot systems
- Learn about the types of actuators used in robotics
- Calculate the forward kinematics and inverse kinematics.
- Learn about programming principles and languages for a robot control system
- Discuss the applications of image processing and machine vision in robotics.

**Course Outcomes:** At the end of the course, the students will be able to

**CO1:** Discuss various applications and components of industrial robot systems.

**CO2:** Learn about the types of actuators used in robotics.

**CO3:** Calculate the forward kinematics and inverse kinematics.

**CO4:** Learn about programming principles and languages for a robot control system.

**CO5:** Discuss the applications of image processing and machine vision in robotics.

**UNIT – I:**

**INTRODUCTION:** Automation and Robotics, CAD/CAM and Robotics – An overview of Robotics – present and future applications – classification by coordinate system and control system.

**COMPONENTS OF THE INDUSTRIAL ROBOTICS:**

Robot anatomy, work volume, components, number of degrees of freedom - robot drive systems, function line diagram representation of robot arms, common types of arms – requirements, challenges and design of end effectors.

**UNIT – II:**

**ROBOT ACTUATORS AND FEEDBACK COMPONENTS:**

**Actuators:** Pneumatic, Hydraulic actuators, Electric & stepper motors. Comparison of Electric, Hydraulic and Pneumatic types of actuation devices.

**Feedback components:** Position sensors – potentiometers, resolvers, encoders – velocity sensors.

**UNIT – III:**

**MOTION ANALYSIS:** Homogeneous transformations as applicable to rotation and translation – problems.

**MANIPULATOR KINEMATICS:** Specifications of matrices, D–H notation joint coordinates and world coordinates Forward and inverse kinematics – problems.

**UNIT – IV:**

**GENERAL CONSIDERATIONS IN PATH DESCRIPTION AND GENERATION:** Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint integrated motion – straight line motion – Robot programming, languages and software packages – description of paths with a robot programming language.

**UNIT – V:**

**IMAGE PROCESSING AND MACHINE VISION:** Introduction to Machine Vision, Sensing and Digitizing function in Machine Vision, Training and Vision System, Robotic Applications.

**Text Books:**

1. M. P. Groover, Industrial Robotics: Technology, Programming and Applications, 2/e, McGraw Hill Education, 2017.

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| 2. Mittal R.K. and Nagrath I.J., Robotics and Control, Tata McGraw-Hill, 2003. |
| **Reference Books:** |
| 1. Fu K. S., Gonzalez R. C., and Lee C. S. G., Robotics: Control, Sensing, Vision, and Intelligence, McGraw-Hill, 1987. |
| 2. Richard D. Klafter, Thomas A. Chmielewski, and Michael Negin, Robotic Engineering: An Integrated Approach, Prentice Hall, 1989. |
| 3. H. Asada and J. J. E. Slotine, Robot Analysis and Control, Wiley, Reprint Edition by BSP Books Pvt. Ltd., 2012. |
| 4. John J. Craig, Introduction to Robotics: Mechanics and Control, 3/e, Pearson Education, 2005. |
| 5. Saha S. K., Introduction to Robotics, Tata McGraw-Hill Education, 2008. |
| **Online Learning Resources:** |
| • https://onlinecourses.nptel.ac.in/noc23_me143/preview |
| • https://onlinecourses.nptel.ac.in/noc21_me76/preview |
| • https://onlinecourses.nptel.ac.in/noc21_me32/preview |
| • https://www.coursera.org/courses?query=robotics |
| • https://www.udemy.com/topic/industrial-robotics/?srsltid=AfmBOoo5ILvtEieF64GFjStmDELMdecI2iYbEu0TYew-CuQ47-KVZK3S |

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**JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA**

**B.Tech III Year II Semester**

**23AME65B - WORK STUDY & INDUSTRIAL ERGONOMICS**

**{OPEN ELECTIVE – II (B)}**

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**Course Objectives:** The objectives of the course are to make the students learn about

- Familiarize the fundamentals of human factors in engineering.
- Explain principles Hours Anthropometry, Ergonomics and product design.
- Describe the Improvement of human work place through controls.
- Evaluate the sources of vibration and performance effect of vibration in machine tools.
- Know the Special purpose lighting for illumination and quality control.

**Course Outcomes:** At the end of the course, the students will be able to

**CO1:** Describe the human factors in engineering.

**CO2:** Identify physical dimensions of the human body as a working machine

**CO3:** Illustrate the design of major controls in automobiles and machine tools.

**CO4:** State the design of major controls in automobiles and machine tools, Principles of hand tool design.

**CO5:** Identify the sources of vibration and performance effect of vibration is machine tools.

**UNIT – I:**

**Fundamentals of Human Factors Engineering:** Human Biological, Ergonomic and psychological capabilities and limitations, Concepts of human factors engineering and ergonomics, Man–Machine system and Design philosophy.

**Physical work and energy expenditure:** Manual lifting, Work posture, Repetitive motion, Provision of energy for muscular work, Heat stress, Role of oxygen physical exertion, Measurement of energy expenditure, Respiration, Pulse rate and blood pressure during physical work, Physical work capacity and its evaluation.

**UNIT – II:**

**Hours Anthropometry:** Physical dimensions of the human body as a working machine, Motion size relationships, Static and dynamic anthropometry, Anthropometric design principles, Using anthropometric measures for industrial design.

**Ergonomics and product design:** Ergonomics in automated systems, Expert systems for ergonomic design, Anthropometric data and its application in ergonomic design, Limitations of anthropometric data, Use of computerized database.

**UNIT – III:**

**Machine controls:** Improvement of human work place through controls, Displays and Controls, Shapes and sizes of various controls and displays, Multiple display and control situations, Design of major controls in automobiles and machine tools, Principles of hand tool design.

**Work place and seating design:** Design of office furniture, Redesign of instruments, Work process: Duration of rest periods, Design of visual displays, Design for shift work.

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**UNIT – IV:**

**Color and light:** Color and light: Color and the eye, Color consistency, Color terms, Reactions to color and color continuation, Color on engineering equipment's.

**Temperature-Humidity-Illumination and Contrast:** Use of Photometers, Recommended illumination levels, The ageing eye, Use of indirect (Reflected) lighting, Cost efficiency of illumination, Special purpose lighting for illumination and quality control.

**UNIT – V:**

**Hours Measurement of sound:** Hours Measurement of sound: Noise exposure and hearing loss, Hearing protectors, Analysis and reduction of noise, Effects of noise, Performance annoyance of noise and interface with communication, Sources of vibration and performance effect of vibration, Vibrations in machine tools.

**Text Books:**


1. M. S. Sanders and E. J. McCormick, Human Factors in Engineering Design, 7/e, McGraw – Hill International, 1993.


**Reference Books:**


1. P. V. Karpovich and W. E. Sinning, Physiology of Muscular Activity, 7/e, Saunders (W.B.) Co Ltd., 1971.
2. Applied Ergonomics Handbook, I.P.C. Science and Technology Press Limited, 1974.
3. M. Helander, A Guide to the Ergonomics of Manufacturing, 2/e, CRC Press, 1997.
4. K. H. E. Kroemer, H. B. Kroemer and K. E. Kroemer Elbert, Ergonomics: How to design for ease and efficiency, 2/e, Pearson Publications, 2001.


**Online Learning Resources:**

- https://www.youtube.com/watch?v=a2x-rCNJn3w
- https://onlinecourses.swayam2.ac.in/aic20_ed03/preview
- https://industri.fatek.unpatti.ac.id/wp-content/uploads/2019/03/104-Introduction-to-Human-Factors-and-Ergonomics-for-Engineers-Mark-Lehto-Steven-J.-Landry-Edisi-2-2012.pdf
- https://kuliahdianmardi.files.wordpress.com/2016/03/handbook-of-human-factors-and-ergonomics-fourth-edition-2012.pdf
- https://oer.galileo.usg.edu/cgi/viewcontent.cgi?article=1000&context=engineering-collections

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**JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA**

**B.Tech III Year II Semester**

**23AME65C - COUSTOMER RELATIONSHIP MANAGEMENT**

**(OPEN ELECTIVE – II(C))**

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**Course Objectives:** The objectives of the course are to make the students learn about

- Introduce basic concepts and principles of customer relationship management (CRM).
- Familiarize with appreciate the role and changing face of CRM as an IT enabled function.
- Describe concept of managing and sharing customer data.
- Explain the principles of CRM links in e-Business.
- Expose the students on Enterprise Resource Planning (ERP), Supply Chain Management (SCM) and Supplier Relationship Management (SRM).

**Course Outcomes:** At the end of the course, the students will be able to

**CO1:** Evaluate Customer Relationship, Analyse success factor of CRM, Understand Customer Loyalty, Levels of Service, Service Level Agreement.

**CO2:** Understand the importance of one–to–one marketing, business objectives of CRM, call centre and customer satisfaction measurement.

**CO3:** Understand the Sale Forces and activities, importance of Enterprise Resource Planning, Supplier Relationship Management, Partner Relationship Management.

**CO4:** Understand the concepts of Analytical CRM, ethics and legalities of data use, data warehousing and data mining, click stream data, collaborative filtering.

**CO5:** Define success factors of CRM and understand CRM tools, manage customer strategies, CRM development team.

**UNIT – I:**

CRM concepts – Acquiring customers, Customer loyalty and optimizing customer relationships, CRM defined – success factors, the three levels of Service/ Sales Profiling, Service Level Agreements (SLAs), creating and managing effective SLAs.

**UNIT – II:**

CRM in Marketing – One–to–one Relationship Marketing – Cross Selling & Up Selling – Customer Retention, Behavior Prediction – Customer Profitability & Value Modeling – Channel Optimization – Event based marketing. CRM and Customer Service – The Call Centre, Call Scripting – Customer Satisfaction Measurement.

**UNIT – III:**

Sales Force Automation – Sales Process, Activity, Contact – Lead and Knowledge Management – Field Force Automation. CRM links in e–Business, e–Commerce and Customer Relationships on the Internet – Enterprise Resource Planning (ERP), Supply Chain Management (SCM), Supplier Relationship Management (SRM), Partner Relationship Management (PRM).

**UNIT – IV:**

Analytical CRM – Managing and sharing customer data, Customer information databases, Ethics and legalities of data use. Data Warehousing and Data Mining concepts – Data analysis – Market Basket Analysis (MBA), Click stream Analysis, Personalization and Collaborative Filtering.

**UNIT – V:**

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| CRM Implementation – Defining success factors – Preparing a business plan requirements, justification and processes. – Choosing CRM tools – Defining functionalities – Homegrown versus out–sourced approaches – Managing customer relationships – conflict, complacency, Resetting the CRM strategy. Selling CRM internally – CRM development Team – Scoping and prioritizing - Development and delivery – Measurement. |
| **Text Books:** |
| 1. Alok Kumar Rai, Customer Relationship Management Concept & Cases, Prentice Hall Of India Private limited, New Delhi. 2011. |
| 2. S. Shanmugasundaram, Customer Relationship Management, Prentice Hall of India Private limited, New Delhi, 2008. |
| **Reference Books:** |
| 1. Kaushik Mukherjee, Customer Relationship Management, Prentice Hall of India Private limited, New Delhi, 2008. |
| 2. Jagdish Seth, Et Al, Customer Relationship Management. |
| 3. V. Kumar & Werner J., Customer Relationship Management, Willey India, 2008. |
| **Online Learning Resources:** |
| • https://nptel.ac.in/courses/110105145 |
| • https://onlinecourses.swayam2.ac.in/imb19_mg10/preview |
| • https://www.classcentral.com/course/swayam-customer-relationship-management-13977 |
| • https://www.edx.org/course/customer-relationship-management |

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| JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA | | | | |
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| **B.Tech III Year II Semester**<br>**23AME65D - HYBRID VEHICLES**<br>**(OPEN ELECTIVE – II(D))** | | | | |
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| **Course Objectives:** The objectives of the course are to make the students learn about | | | | |
| • To provide good foundation on hybrid and electrical vehicles. | | | | |
| • To address the underlying concepts and methods behind power transmission in hybrid and electrical vehicles. | | | | |
| • To familiarize energy storage systems for electrical and hybrid transportation. | | | | |
| • To design and develop basic schemes of electric vehicles and hybrid electric vehicles. | | | | |
| **Course Outcomes:** At the end of the course, the students will be able to | | | | |
| **CO1:** Explain the working of hybrid and electric vehicles. | | | | |
| **CO2:** Choose a suitable drive scheme for developing a hybrid and electric vehicles depending on resources. | | | | |
| **CO3:** Develop the electric propulsion UNIT and its control for application of electric vehicles. | | | | |
| **CO4:** Choose proper energy storage systems for vehicle applications. | | | | |
| **CO5:** Design and develop basic schemes of electric vehicles and hybrid electric vehicles. | | | | |
| **UNIT – I:** | | | | |
| **Introduction to Hybrid and Electric Vehicles:** History of hybrid and electric vehicles, Need for hybrid and electric vehicles and their limitations. Social and environmental importance of hybrid and electric vehicles, impact of modern drive–trains on energy supplies. Specifications of hybrid and electric vehicles. | | | | |
| **UNIT – II:** | | | | |
| **Hybrid Electric Drive-trains:** Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive–train topologies, fuel efficiency analysis.<br>**Electric Drive-trains:** Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. | | | | |
| **UNIT – III:** | | | | |
| **Electric Propulsion unit:** Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency. | | | | |
| **UNIT – IV:** | | | | |
| **Energy Storage:** Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. | | | | |
| **UNIT – V:** | | | | |
| **Sizing the drive system:** Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications,<br>**Design Considerations for Electric Vehicles:** Various Resistance – Transmission efficiency – Vehicle mass – Electric vehicle chassis and Body design considerations – Heating and cooling systems – Power steering – Tire choice – Wing Mirror, Aerials and Luggage racks. | | | | |
| **Text Books:** | | | | |

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1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, 2/e, CRC Press, 2003.
2. Amir Khajepour, M. Saber Fallah, Avesta Goodarzi, Electric and Hybrid Vehicles: Technologies, Modeling and Control–A Mechatronic Approach, illustrated edition, John Wiley & Sons, 2014.
3. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.

**Reference Books:**

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
2. John G. Hayes, G. Abas Goodarzi, Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles, 1/e, Wiley-Blackwell, 2018.

**Online Learning Resources:**

- https://archive.nptel.ac.in/courses/108/103/108103009/
- https://www.youtube.com/watch?v=wypbLRe9xUg
- https://www.youtube.com/watch?v=q6BYr5-fq5U
- https://www.youtube.com/watch?v=3E1SXG7VkQk
- https://www.iarc.ac.in/sites/default/files/IARE_IIEV_LN_0.pdf
- https://nptel.ac.in/courses/108102121

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**JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA**

**B.Tech III Year II Semester**

**23AME65E - INDUSTRIAL SAFETY**

**(OPEN ELECTIVE – II (E))**

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**Course Objectives:** The objectives of the course are to make the students learn about

- Familiarize with the safety in industry.
- Know the wear and corrosion and their prevention.
- Explain Periodic and preventive maintenance.

**Course Outcomes:** At the end of the course, the students will be able to

**CO1:** To understand the fundamental principles of industrial safety.

**CO2:** Understand the fundamentals of maintenance engineering.

**CO3:** To gain knowledge about industrial hazards, legal requirements, and compliance.

**CO4:** Apply fault tracing technique to find the fault in industries.

**CO5:** Compare periodic and preventive maintenance.

**UNIT – I:**

**Industrial Safety:** Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc., Safety color codes. Fire prevention and firefighting – equipment and methods.

**UNIT – II:**

**Fundamentals of maintenance engineering:** Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**UNIT – III:**

**Wear and Corrosion and their prevention:** Wear – types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**UNIT – IV:**

Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault–finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, i. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**UNIT – V:**

**Periodic and Preventive Maintenance:** Periodic inspection – concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: i. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance.

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| **Text Books:** |
| 1. Higgins, L. R., & Morrow, D. J., Maintenance Engineering Handbook, 7/e, McGraw-Hill (Da Information Services is likely a distributor), 2008. |
| 2. H. P. Garg, Maintenance Engineering, S. Chand and Company Ltd., 1990. |
| **Reference Books:** |
| **1.** Audel, Pump and Hydraulic Compressors, McGraw-Hill Publications. (Notc: "Audcl" is a publisher/series name; this may refer to titles like "Audel Pumps and Hydraulics") |
| **2.** Hans F. Winterkorn, Foundation Engineering Handbook, Chapman & Hall, London, 1975. |
| **Online Learning Resources:** |
| • https://www.scribd.com/document/794234066/Industrial-Safety-Fault-Tracing |
| • https://onlinecourses.nptel.ac.in/noc20_mg43/preview |
| • https://archive.nptel.ac.in/courses/110/105/110105094/ |
| • chrome-extension://kdpelmjpfafjppnhbloffcjpeomlnpah/https://www.stannescet.ac.in/cms/staff/qbank/MECH/Notes/CME388-INDUSTRIAL%20SAFETY-915526762-CME%20388%20IS%20NOTES.pdf |
| • https://onlinecourses.swayam2.ac.in/nou23_ge81/preview |

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**JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA**

**B.Tech IV Year I Semester**

**23AME74A - 3D PRINTING TECHNOLOGIES**

**{OPEN ELECTIVE – III (A)}**

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**Course Objectives:** The objectives of the course are to make the students learn about

- Familiarize of additive manufacturing / rapid prototyping and its applications in various fields.
- Impart reverse engineering techniques.
- Explain different processes available in additive manufacturing.
- Bring awareness on mechanical properties of materials and geometric issues related to additive manufacturing applications.

**Course Outcomes:** At the end of the course, the students will be able to

**CO1:** Demonstrate various additive manufacturing and rapid prototyping techniques applications.

**CO2:** Describe different additive manufacturing processes.

**CO3:** Apply methods in rapid prototyping.

**CO4:** Use powder based AM system.

**CO5:** Model 3D printing using SDM and BPM methods.

**UNIT – I:** Introduction to 3D PRINTING Systems:

History and Development of 3D printing, Need of 3D Printing, Difference between 3D Printing and CNC, Classification of 3D Printing Processes: Based on Layering Techniques, Raw Materials and Energy Sources, 3D Printing Process Chain, Benefits and Applications of 3D Printing, Representation of 3D model in STL format, RP data formats: SLC, CLI, RPI, LEAF, IGES, CT, STEP, HP/GL.

**UNIT – II:** CAD & Reverse Engineering

Basic Concept, Digitization techniques, Model Reconstruction, Data Processing for Additive Manufacturing Technology: CAD model preparation, Part Orientation and support generation, Model Slicing, Tool path Generation, Software's for Additive Manufacturing Technology: MIMICS, MAGICS. Reverse Engineering (RE) –Meaning, Use, RE – The Generic Process, Phase of RE Scanning, Contact Scanners, Noncontact Scanners, Point Processing, Application Geometric Model, Development.

**UNIT – III:** Solid and Liquid Based AM Systems

Laminated Object Manufacturing (LOM): Principle, Process, Materials, Advantages, Limitations, Applications.

Solid Ground Curing (SGC): Principle, Process, Materials, Advantages, Limitations, Applications. Fusion Deposition Modeling (FDM): Principle, Process, Materials, Advantages, Limitations, Applications.

Stereolithography Apparatus (SLA): Principle, Process, Materials, Advantages, Limitations and Applications.

**UNIT – IV:** Powder Based AM Systems

Principle and Process of Selective Laser Sintering (SLS), Advantages, Limitations and Applications of SLS, Principle and Process of Laser Engineered Net Shaping (LENS), Advantages, Limitations and Applications of LENS, Principle and Process of Electron Beam Melting (EBM), Advantages, Limitations and Applications of EBM.

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| **UNIT – V:** Other AM Systems |
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| Three Dimensional Printing (3DP): Principle, Process, Advantages, Limitations and Applications. Ballistic Particle Manufacturing (BPM): Principle, Process, Advantages, Limitations, Applications. Shape Deposition Manufacturing (SDM): Principle, Process, Advantages, Limitations, Applications. |
| **Text Books:** |
| 1. Ian Gibson, David W. Rosen, Brent Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, 1/e Springer, 2010. |
| 2. Chua C.K., Leong K.F. and Lim C.S., Rapid Prototyping: Principles and Applications, 2/e World Scientific Publishers, 2003. |
| 3. Liou W. Liou, Frank W., Liou, Rapid Prototyping and Engineering Applications: A Tool Box for Prototype Development, CRC Press, 2007. |
| **Reference Books:** |
| 1. Pham D.T. and Dimov S.S., Rapid Manufacturing; The Technologies and Application of RPT and Rapid Tooling, Springer, London 2001. |
| 2. Gebhardt A., Rapid prototyping, Hanser Gardener Publications, 2003. |
| 3. Hilton P.D. and Jacobs P.F., Rapid Tooling: Technologies and Industrial Applications, CRC Press, 2005. |
| 4. Rafiq Noorani, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons, 2006. |
| **Online Learning Resources:** |
| • https://www.hubs.com/knowledge-base/introduction-fdm-3d-printing/ |
| • https://slideplayer.com/slide/6927137/ |
| • https://www.mdpi.com/2073-4360/12/6/1334 |
| • https://www.centropiaggio.unipi.it/sites/default/files/course/material/2013-11-29%20-%20FDM.pdf |
| • https://lecturenotes.in/subject/197 |

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**JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA**

**B.Tech IV Year I Semester**

**23AME74B - INTRODUCTION TO MECHATRONICS**

**{OPEN ELECTIVE – III (B)}**

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**Course Objectives:** The objectives of the course are to make the students learn about

- To gain knowledge on Mechatronic based systems and its applications.
- To Impart Knowledge on various types of sensors and transducers used in mechatronic system to measure various physical parameters
- To Incorporate knowledge about various solid state electronic devices
- To Design hydraulic and pneumatic circuits according to the desired application
- To be familiar with concepts of microcontrollers and microprocessors and PLC.

**Course Outcomes:** At the end of the course, the students will be able to

CO1: Describe the basic components and functioning of mechatronic system.

CO2: Select the sensors for the desired application

CO3: Revise the concepts of solid state electronic devices

CO4: Explain the fundamental principles and working of various types of actuators.

CO5: Interface microcontrollers and microprocessors with sensors, actuators and other peripherals.

**UNIT – I:**

**Introduction:** Scope and Significance of Mechatronic systems, Elements of Mechatronic system, Need and Benefits of Mechatronics in Manufacturing, Control systems, Overview of mechatronic products, Microprocessor based controllers.

Case studies: Automatic Flush Tank, Car Engine Management System, Automatic Washing Machine, Automatic camera, Pick and Place Robot.

**UNIT – II:**

**Sensors and Transducers:** Sensor – Classification, Performance terminology, Selection of sensors, sensors for displacement, force, fluid pressure, liquid flow, light senesors, potentiometers, LVDT, Encoders, Strain gauges, Load cells, temperature sensors, Tachometers, Proximity and Tactile sensors, Micro Switch, Read Switch and Vision Sensors.

**UNIT – III:**

**Solid State Electronic Devices:** PN Junction diode, BJT, FET, DIAC and TRIAC, Analog Signal Conditioning, Operational Amplifiers, Noise reduction, Filtering. Digital Signal Processing.

**UNIT – IV:**

**Actuators:** Hydraulic Actuation, Pneumatic Actuation, Mechanical Actuation and Electrical Actuation Systems – Basic Principles and elements. Electro hydraulic, Electro Pneumatic and Electro mechanical drives.

**UNIT – V:**

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| **Microcontrollers Overview:** 8051 Microcontroller , Microprocessor Architecture - Digital Interfacing - Analog Interfacing - Digital to Analog Convertors - Analog to Digital Convertors - Applications.<br><br>**Programmable Logic Controllers:** Basic Structure - Programming: Ladder diagram - Timers, Internal Relays and Counters - Shift Registers - Master and Jump Controls - Data Handling - PLC Selection – Applications |
| **Text Books:** |
| 1. Mechatronics Electronics Control Systems in Mechanical and Electrical Engineering , W Bolton, Pearson Education Press, 3/e, 2005. |
| 2. Mechatronic System Design. Devdas Shetty, Richard A. Kolk, Cengage Learning , 2010. |
| 3. Mechatronics, Ganesh.S.H, Jones and Bartlett publications. |
| **Reference Books:** |
| 1. Newton C. Braga, Mechatronics Source Book, 1/e, Thomson/Delmar Learning, Chennai, 2003. |
| 2. N. Shanmugam, Mechatronics, 1/e, Anuradha Agencies Publishers, Chennai, 2010. |
| 3. Devdas Shetty and Richard A. Kolk, Mechatronics System Design, 2/e, Thomson Learning/Cengage, 1997, 1st Edition; 2010. |
| 4. M. D. Singh and J. G. Joshi, Mechatronics, 1/e, PHI Learning Pvt. Ltd., New Delhi, 2006. |
| **Online Learning Resources:** |
| • https://www.srecwarangal.ac.in/ece-downloads/Mechatronics%20material.pdf |
| • https://kp.kiit.ac.in/pdf_files/06/SM_5th-SEM_Mech_Mechatronics.pdf |
| • https://www.cet.edu.in/noticefiles/259_Lecturer%20Note%20on%20Mechatronics-ilovepdf-compressed.pdf |
| • https://archive.nptel.ac.in/courses/112/107/112107298/ |
| • https://nptel.ac.in/courses/112103174 |

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**JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA**

**B.Tech IV Year I Semester**

**23AME74C - ROBOT PROGRAMMING**

**{OPEN ELECTIVE – III (C)}**

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**Course Objectives:** The objectives of the course are to make the students learn about

- Learn the fundamental concepts of industrial robotic technology.
- Apply the basic mathematics to calculate kinematic and dynamic forces in robot manipulator.
- Understand the robot controlling and programming methods.
- Describe concept of robot vision system.

**Course Outcomes:** At the end of the course, the students will be able to

**CO1:** Explain fundamentals of Robots.

**CO2:** Apply kinematics and differential motions and velocities.

**CO3:** Demonstrate control of manipulators.

**CO4:** Understand robot vision.

**CO5:** Develop robot cell design and programming.

**UNIT – I:**

Fundamentals of Robots

Introduction, definition, classification and history of robotics, robot characteristics and precision of motion, advantages, disadvantages and applications of robots.

**UNIT – II:**

Robot Actuators And Feedback Components

Actuators, Pneumatic, Hydraulic actuators, Electric & Stepper motors, comparison. Position sensors – potentiometers, resolvers, encoders - velocity sensors, Tactile sensors, Proximity sensors.

**UNIT – III:**

Robot Programming

Methods of programming - requirements and features of programming languages, software packages, problems with programming languages. VAL, RAIL, AML, C, C++.

**UNIT – IV:**

Control of Manipulators

Open and close – loop control, the manipulator control problem, linear control schemes, characteristics of second-order linear systems, linear second-order SISO model of a manipulator joint, joint actuators, partitioned PD control scheme, PID control Scheme, computer Torque control, force control of robotic manipulators, description of force-control tasks, force control strategies, hybrid position/force control, impedance force/torque control.

**UNIT – V:**

Robot Vision

Introduction, architecture of robotic vision system, image processing, image acquisition camera, image enhancement, image segmentation, imaging transformation, Camera transformation and calibrations, industrial applications of robot vision.

**Text Books:**

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1. Mikell P. Groover and Mitchell Weiss, Roger N. Nagel,Nicholas G.Odrey , Industrial Robotics — McGraw Hill, 1986.
2. R K Mittal and I J Nagrath, Robotics and control, Illustrated Edition, Tata McGraw Hill India 2003.

**Reference Books:**

1. Saeed B. Niku, Introduction to Robotics – Analysis, System, Applications, 2/e, John Wiley & Sons, 2010.
2. H. Asada and J.J.E. Slotine, Robot Analysis and Control, 1/e, Wiley- Inter science, 1986.
3. Robert J. Schillin, Fundamentals of Robotics: Analysis and control, Prentice-Hall Of India Pvt. Limited, 1996.
4. Mohsen shahinpoor, A robot Engineering text book, Harper & Row Publishers, 1987.
5. John.J.Craig Addison, Introduction to Robotics: Mechanics and Control, Wesley, 1999.
6. K.S. FU, R.C. Gonzalez and C.S.G Lee, Robotics: Control, sensing, vision, and intelligence. Mc Graw Hill, 1987.
7. Richard D. Klafter, Thomas Robotic Engineering an integrated approach, PHI publications 1988.

**Online Learning Resources:**

- https://nptel.ac.in/courses/112105249
- https://onlinecourses.nptel.ac.in/noc20_de11/preview
- https://nptel.ac.in/courses/112104308
- https://nptel.ac.in/courses/112104288
- https://nptel.ac.in/courses/112101099
- https://www.iare.ac.in/sites/default/files/lecture_notes/ROBOTICS_LECURE_NOTES.pdf

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**JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA**

**B.Tech IV Year I Semester**

**23AME74D - PRODUCT DESIGN AND DEVELOPMENT**

**{OPEN ELECTIVE – III (D)}**

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**Course Objectives:** The objectives of the course are to make the students learn about

- To Design products creatively while applying engineering design principles
- To Apply principles of human factors, ethics and environmental factorsin product design
- To Work in groups or individually in their pursuit of innovative product design
- To implement value design for optimum product cost.

**Course Outcomes:** At the end of the course, the students will be able to

**CO1:** Apply knowledge of basic science and engineering fundamentals.

**CO2:** Undertake problem identification, formulation and solution.

**CO3:** Understanding of the principles of sustainable design and development.

**CO4:** Understanding of professional and ethical responsibilities and commitment to them.

**CO5:** Identify the Mechanical connections, mechatronics and adaptronics

**UNIT – I:**

**PRODUCT DEVELOPMENT PROCESS:** General problem solving process - Flow of Work during the process of designing - Activity Planning Timing and scheduling, Planning Project and Product Costs - Effective Organization Structures - Interdisciplinary Cooperation, Leadership and Team behaviour.

**UNIT – II:**

**TASK CLARIFICATION:** Importance of Task Clarification - Setting up a requirements list - Contents, Format, Identifying the requirements, refining and Extending the requirements, Compiling the requirements list, Examples. Using requirements lists - Updating, Partial requirements lists, Further uses - Practical applications of requirements lists.

**UNIT – III:**

**CONCEPTUAL DESIGN:** Steps in Conceptual Design. Abstracting to identify the essential problems - Aim of Abstraction, Broadening the problem. Formulation, Identifying the essential problems from the requirements list, Establishing functions structures, Overall function, Breaking a function down into sub-functions. Developing working structures - Searching for working principles, Combining Working Principles, Selecting Working Structures, Practical Application of working structures. Developing Concepts - Firming up into principle solution variants, Evaluating principle solution variants, Practical Applications of working structures. Examples of Conceptual Design - One Handed Household Water Mixing Tap, Impulse - Loading Test Rig.

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**UNIT – IV:**

**EMBODIMENT DESIGN** - Steps of Embodiment Design, Checklist for Embodiment Design

Basic rules of Embodiment Design Principles of Embodiment Design - Principles of Force Transformations, Principles of Division of Tasks, Principles of Self-Help, Principles of Stability and Bi-Stability, Principles of Fault-Free Design Guide for Embodiment Design - General Considerations, Design to allow for expansion, Design to allow for creep and relaxation, Design against Corrosion, Design to minimize wear, Design to Ergonomics, Design for Aesthetics, Design for Production, Design for Assembly, Design for Maintenance, Design for Recycling, Design for Minimum risk, Design to standards. Evaluation of Embodiment Designs.

**UNIT – V:**

**MECHANICAL CONNECTIONS, MECHATRONICS AND ADAPTRONICS:** Mechanical Connections - General functions and General Behaviour, Material connections, From Connections, Force connections, Applications. Mechatronics - General Architecture and Terminology, Goals and Limitations, Development of Mechatronic Solution, Examples. Adaptronics - Fundamentals and Terminology, Goals and Limitations, Development of Adaptronics Solutions, Examples.

**Text Books:**

1. Engineering Design: G.Paul; W. Beitzetal, Springer International Education 2010.
2. Product Design and Development: Kevin Otto: K. Wood Pearson Education 2013.

**Reference Books:**

1. Product Planning Essentials: Kenith B. Kahu, Yes dee Publishing 2011.
2. Product Design and Development: K.T. Ulrich TMH Publishers 2011.

**Online Learning Resources:**

- https://onlinecourses.nptel.ac.in/noc21_me83/preview
- https://archive.nptel.ac.in/courses/112/107/112107217/
- https://nptel.ac.in/courses/112104230
- https://onlinecourses.swayam2.ac.in/imb19_mg01/preview

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**JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA**

**B.Tech IV Year I Semester**

**23AME74E - DIGITAL MARKETING MANAGEMENT**

**{OPEN ELECTIVE – III (E)}**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**Course Objectives:** The objectives of the course are to make the students learn about

- To understand the digital marketing.
- To identify the marketing automation software's available.
- To understand the concept of online advertisement methods.
- To understand the importance of email marketing.
- To the principles of blogs and importance of blogs

**Course Outcomes:** At the end of the course, the students will be able to

**CO1:** Understand the concept of digital marketing and its real-world iterations

**CO2:** Articulate innovative insights of digital marketing enabling a competitive edge

**CO3:** Understand how to create and run digital media based campaigns

**CO4:** Identify and utilise various tools such as social media etc.

**CO5:** Creation of blogs for digital marketing

**UNIT – I:**

Introduction to Digital Marketing (DM)-Meaning, Definition, Need of DM, Scope of DM, Historyof DM, Concept and approaches to DM, Examples of good practices in DM.

**UNIT – II:**

Marketing Automation: Definition, Advantages, Marketing Automation Softwares: CRM, Sales force, Analytics; Customer Experience (CX), How does marketing automation help marketers, Marketing automation tools.

**UNIT – III:**

Digital Marketing Mix: Online Advertising, Lead Generation, Social Media Marketing, Content and Copywriting. Influencer Marketing: Influencer, Payment to Influencer, difference between influencer marketing and celebrity endorsements.

**UNIT – IV:**

Email Marketing- Need for Emails, Types of Emails, options in Email advertising, Features of MailChimp, Mobile Marketing: Overview of the B2B and B2C Mobile Marketing.

**UNIT – V:**

What are Blogs, Importance of Blogs, Personal Blogs, Corporate Blogs, Popular Blog Platforms, What are Tags, Widgets, Blog Optimization, and Blog Stats.

**Text Books:**


1. Dave Evans, Susan Bratton, Social Media Marketing: The Next Generation of Business Engagement, 1/e, Wiley, 2010.
2. Joel Teixeira, Your Google Game Plan for Success: Increasing Your Web Presence with Google AdWords, Analytics and Website Optimizer, 1/e, Wiley, 2010.


**Reference Books:**


1. Michael J. Thibault, The Influencer Blueprint: A Step-by-Step Guide to Harnessing the Power of Influencer Marketing for Business Success, 1/e, 2023.


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|---|
| 2. George Pain, Marketing Automation and Online Marketing: Automate Your Business through Marketing Best Practices such as Email Marketing and Search Engine Optimization, 1/e, 2019. |
| 3. Stevan Roberts, Marketing AI: From Automation to Revenue Performance Marketing, 1/e, 2016. |
| 4. Jodie the Mom, Email Marketing Planner: Organize and Track Your Emails, 1/e, 2023. |
| **Online Learning Resources:** |
| • https://onlinecourses.swayam2.ac.in/ugc19_hs26/preview |
| • https://www.shiksha.com/online-courses/basics-of-digital-marketing-by-nptel-course-nptel43 |
| • https://archive.nptel.ac.in/courses/110/104/110104070/ |

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**JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA**

**B.Tech IV Year I Semester**

**23AME75A - TOTAL QUALITY MANAGEMENT**

**{OPEN ELECTIVE – IV (A)}**

| L | T | P | C |
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| 3 | 0 | 0 | 3 |

**Course Objectives:** The objectives of the course are to make the students learn about

- Introduce the students, the basic concepts of Total Quality Management.
- Expose with various quality issues in Inspection.
- Gain Knowledge on quality control and its applications to real time.
- Know the extent of customer satisfaction by the application of various quality concepts.
- Understand the importance of Quality standards in Production

**Course Outcomes:** At the end of the course, the students will be able to

**CO1:** Develop an understanding on quality Management philosophies and frameworks.

**CO2:** Adopt TQM methodologies for continuous improvement of quality.

**CO3:** Measure the cost of poor quality, process effectiveness and efficiency to identify areas for improvement.

**CO4:** Apply benchmarking and business process reengineering to improve management processes.

**CO5:** Determine the set of indications to evaluate performance excellence of an organization.

**UNIT – I:**

Introduction: Definition of Quality, Dimensions of Quality, Definition of Total quality management, Quality Planning, Quality costs – Analysis, Techniques for Quality costs, Basic concepts of Total Quality Management.

**UNIT – II:**

Quality council, Quality statements, Strategic Planning, Deming Philosophy, Barriers of TQM Implementation, Benefits of TQM, Characteristics of successful quality leader, Contributions of Gurus of TQM, Case studies.

**UNIT – III:**

**TQM Principles:**

Customer Satisfaction – Customer Perception of Quality, Customer Complaints, Service Quality, Customer Retention, Employee Involvement – Motivation, Empowerment teams, Continuous Process Improvement – Juran Trilogy, PDSA Cycle, Kaizen, Supplier Partnership – Partnering, sourcing, Supplier Selection, Supplier Rating, Relationship Development, Performance Measures – Basic Concepts, Strategy, Performance Measure Case studies.

**UNIT – IV:**

**TQM Tools**

Benchmarking – Reasons to Benchmark, Benchmarking Process, Quality Function Deployment (QFD) – House of Quality, QFD Process, Benefits, Taguchi Quality Loss Function, Total Productive Maintenance (TPM) – Concept, Improvement Needs, FMEA – Stages of FMEA, The seven tools of quality, Process capability, Concept of Six Sigma, New Seven management tools, Case studies.

**UNIT – V:**

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| **Quality Systems**<br>Need for ISO 9000 and Other Quality Systems, ISO 9000: 2000 Quality System – Elements, Implementation of Quality System, Documentation, Quality Auditing, QS 9000, ISO 14000 – Concept, Requirements and Benefits, Case Studies. |
| **Text Books:** |
| 1. Dale H Besterfield, Total Quality Management, Fourth Edition, Pearson Education, 2015. |
| 2. Subburaj Ramaswamy, Total Quality Management, Tata Mcgraw Hill Publishing Company Ltd., 2005. |
| 3. Joel E.Ross , Total Quality Management, Third Eition, CRC Press, 2017. |
| **Reference Books:** |
| 1. Narayana V and Sreenivasan N.S, Quality Management – Concepts and Tasks, New Age International, 1996. |
| 2. Robert L.Flood, Beyond TQM, First Edition, John Wiley & Sons Ltd, 1993. |
| 3. Richard S. Leavenworth & Eugene Lodewick Grant, Statistical Quality Control, Seventh Edition, Tata Mcgraw Hill, 2015 |
| 4. Samuel Ho , TQM – An Integrated Approach, Kogan Page Ltd, USA, 1995. |
| **Online Learning Resources:** |
| • https://www.youtube.com/watch?v=VD6tXadibk0 |
| • https://www.investopedia.com/terms/t/total-quality-management-tqm.asp |
| • https://blog.capterra.com/what-is-total-quality-management/ |
| • https://nptel.ac.in/courses/110/104/110104080/ |
| • https://onlinecourses.nptel.ac.in/noc21_mg03/preview |

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**JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA**

**B.Tech IV Year I Semester**

**23AME75B - OPTIMIZATION TECHNIQUES**

**{OPEN ELECTIVE – IV (B)}**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**Course Objectives:** The objectives of the course are to make the students learn about

- Principles of optimization and its need.
- Learn classical optimization techniques and numerical methods of optimization.
- Numerical optimization techniques for single variable and multi variable non – linear optimization problems.
- Geometry cutting plane method & branch bound method for linear programming problem.
- Formulation of Geometric Programming model and solving it using arithmetic geometric inequality theorem.

**Course Outcomes:** At the end of the course, the students will be able to

**CO1:** Identify optimization methods and algorithms developed for solving various types of optimization problems.

**CO2:** Use classical optimization techniques and numerical methods of optimization.

**CO3:** Understand and apply numerical optimization techniques for single variable and multi variable non – linear optimization problems.

**CO4:** Solve integer programming problem by either geometry cutting plane algorithm or branch band method.

**CO5:** Formulate Geometric Programming model and solve it.

**UNIT – I:**

**Introduction to Optimization:** Engineering applications of optimization, Statement of an optimization problem, Classification of optimization problem, Optimization techniques.

**Classical Optimization Techniques:** Single variable optimization, Multivariable optimization with equality constraints, Multivariable optimization with inequality constraints.

**UNIT – II:**

**Nonlinear Programming:** One-Dimensional Minimization – Uni modal Function, Elimination Methods, Unrestricted Search, Exhaustive Search, Fibonacci Method, Golden Section Method, Interpolation Methods – Quadratic Interpolation Method, Cubic Interpolation Method, Direct Root Method.

**UNIT – III:**

**Nonlinear Programming:** Unconstrained Optimization Techniques – Direct Search Methods, Random Search Methods, Univariate Method, Pattern Search Method, Rosenbrock's Method of rotating coordinates, The Simplex Method, Descent Methods, Gradient of Function, Steepest Descent Method, Conjugate Gradient Method (Fletcher-Reeves method), Quasi – Newton Methods, Variable metric method (Davidon Fletcher, Powell method).

**UNIT – IV:**

**Nonlinear Programming:** Constrained Optimization Techniques, Characteristics of a Constrained Problem, Direct Method, The Complex Method, Cutting Plane Method, Methods of Feasible Directions, Indirect Methods, Transformation Techniques, Basic Approach in the Penalty Function Method, Interior Penalty Function Method, Convex Programming Problem, Exterior Penalty Function Method.

**UNIT – V:**

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| **Integer Programming:** Gomory's Cutting – Plane Method, Branch and Bound method.<br>**Geometric Programming:** Introduction, Polynomial, Unconstrained Geometric Programming, Constrained Geometric Programming, Complementary Geometric Programming. |
| **Text Books:** |
| 1. Singiresu S. Rao, Engineering Optimization, 3rd Edition, New Age Publishers, 2010. |
| 2. Kalyanmoy Deb, Optimization for Engineering Design: Algorithms and Examples, 2nd Edition, PHI Learning Pvt. Ltd., 2012. |
| **Reference Books:** |
| 1. Jasbir S. Arora, Introduction to Optimum Design, 4th Edition, Academic Press, 2016. |
| 2. Ravindran A., Engineering Optimization Methods and Applications, 2nd Edition, John Wiley and Sons, 2006. |
| 3. Fox R.L., Optimization Methods for Engineering Design, 1st Edition, Addison Wesley Publication Co., 1971. |
| |
| **Online Learning Resources:** |
| • https://nptel.ac.in/courses/111105039 |
| • https://archive.nptel.ac.in/courses/111/105/111105039/ |
| • https://www.youtube.com/watch?v=aJKuM4U-eYg |
| • https://onlinecourses.nptel.ac.in/noc21_me10/preview |
| • https://archive.nptel.ac.in/courses/105/103/105103210/ |

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**JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA**

**B.Tech IV Year I Semester**

**23AME75C - ADVANCED MANUFACTURING SYSYTEMS**

**{OPEN ELECTIVE – IV (C)}**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**Course Objectives:** The objectives of the course are to make the students learn about

- Provide an integrated, effective and practical platform for create facilities for teaching, training and research & development work for post-graduate studies in various fields of manufacturing technology.
- Link up with national and international colleges/ universities of excellence to impart the education, maintain quality & content of curriculum and award degree certificates in post-Graduation / Doctorates.
- Provide facilities for international and national subject experts to stay, teach and conduct research projects / programmes on mutual exchange and recognition basis.

**Course Outcomes:** At the end of the course, the students will be able to

**CO1:** Analyze technical problems, propose solutions and document with written and oral reports.

**CO2:** Employ technology for communications, data collection, analysis, simulation and control.

**CO3:** Use Basic Project management skills, project team work and ethical behavior.

**CO4:** Machine variety materials using a conversational and CNC lathe, milling machine and grinder.

**CO5:** Use the basic manufacturing methods, measurements, automation and quality control.

**UNIT – I:**

Surface Processing Operations: Plating and Related Processes, Conversion Coatings, Physical Vapor Deposition, Chemical Vapor Deposition, Organic Coatings, Porcelain Enameling and other Ceramic coatings, Thermal and Mechanical Coating Processes.

**UNIT – II:**

Mechanical Energy Based NTM Process: Elements of the process, mechanics of metal removal, process parameters, effect of process parameters on surface finish and metal removal rate, economic considerations, applications and limitations, recent developments in Abrasive Jet Machining, Water Jet Machining, Abrasive Water Jet Machining and Ultrasonic Machining.

**UNIT – III:**

Electro – Chemical Energy Based NTM Process: Electro - Chemical Machining: Fundamentals of electro chemical machining, metal removal rate in ECM, Tool design, Surface finish and accuracy economics aspects of ECM.

Electro Discharge Machining: General Principle and applications of EDM, Mechanics of metal removal, Process parameters, selection of tool electrode and dielectric fluids, methods surface finish and machining accuracy, Wire EDM.

**UNIT – IV:**

Thermo Electric Based NTM : Electron Beam Machining: Generation and control of electron beam for machining, theory of electron beam machining, principle, advantages, and limitations, comparison of thermal and non-thermal processes.

Plasma Arc Machining: Principle, machining parameters, effect of machining parameters on surface finish and metal removal rate, applications, limitations.

Laser Beam Machining: Principle, effect of machining parameters on surface finish, applications and limitations.

| UNIT – V: |
|---|
| Additive Manufacturing: Additive Manufacturing: Definition, Classification of AM Processes, Steps in AM Process, Fused Deposition Method, Steriolithography, Selective Laser sintering, Laminated Object Manufacturing, and 3D Printing – Working principle, applications and limitations. |
| **Text Books:** |
| 1. V. K. Jain, Advanced Machining Processes, 1/e, Allied Publishers Private Limited, 2009. |
| 2. Mikell P. Groover, Fundamentals of Modern Manufacturing, —/e, John Wiley & Sons Publishers, —. |
| 3. Serope Kalpakjian, Steven R. Schmid, Manufacturing Engineering and Technology, —/e, Pearson, |
| 4. P. C. Pandey, H. S. Shan, Modern Machining Process, 1/e, Tata McGraw-Hill Education, 1980. |
| 5. T. Jagadeesha, Unconventional Machining Processes, 1/e, I.K. International Publishing House, 2016. |
| 6. Ian Gibson, David W. Rosen, Brent Stucker, Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing, 1/e, Springer, 2010. |
| **Reference Books:** |
| 1. P. N. Rao, Manufacturing Technology – Foundry, Forming & Welding, 5/e, McGraw Hill Education (India) Private Limited, 2018. |
| 2. Amitabha Ghosh & Asok Kumar Mallik, Manufacturing Science, 2/e, East-West Press, 2010. |
| **Online Learning Resources:** |
| ▪ https://nptel.ac.in/courses/112/107/112107078/ |
| • https://youtu.be/t3y_Ys3LgGM |
| ▪ https://www.youtube.com/watch?v=E4VZ_rFqpG4&t=1s |
| ▪ https://youtu.be/-tcaR7oSx_w |
| ▪ https://youtu.be/Uybg6VDLoRQ |

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**JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA**

**B.Tech IV Year I Semester**

**23AME75D - OPERATIONS MANAGEMENT**

**{OPEN ELECTIVE – IV (D)}**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**Course Objectives:** The objectives of the course are to make the students learn about

- Introduction to the technical design and manufacturing operations and supply management to the sustainability of an enterprise.
- Need for forecasting and types of forecasting.
- Import the basic principles of project management and other business functions such as value engineering, purchasing, marketing, finance etc.
- Analyze the new demands of the globally competitive business environment that supply chain managers face today.
- Knowledge on various scheduling algorithms applicable to single machine, parallel machines, flow shop and job shop models.

**Course Outcomes:** At the end of the course, the students will be able to

**CO1:** Demonstrate the operations and supply management to the sustainability of an enterprise.

**CO2:** Identify the need for forecasting and understand different forecasting methods.

**CO3:** Identify various production and plant layouts.

**CO4:** Recommend the production schedule for productivity.

**CO5:** Design, analyze and implement single machine, parallel machine, flow shop and job shop scheduling algorithms

**UNIT – I:**

Introduction: Operations Management – Definition, Objectives, Types of Production System, Difference between OM & PM, Historical Development of Operations Management, Current Issues in Operation Management, Product Design – Requirements of Good Product Design, Product Development – Approaches, Concepts in Product Development, Standardization, Simplification, Speed to Market, Introduction to Concurrent Engineering.

**UNIT – II:**

Forecasting: Introduction, Statistical Forecasting Techniques, Moving Averages, Exponential Smoothing Technique, Errors in Forecasting and Evaluation of Forecasting Techniques.

**UNIT – III:**

Value Engineering and Plant Layout: Value Engineering – Objectives, Types of Values, Function and Cost, Product Life Cycle, Steps in Value Engineering, Methodology in Value Engineering, FAST Diagram and Matrix Method. Facility Location and Layout – Factor Considerations in Plant Location, Comparative Study of Rural and Urban Sites, Methods of Selection of Plant Layout, Objectives of Good layout, Principles, Types of Layout, Line Balancing

**UNIT – IV:**

Aggregate Planning and MRP: Aggregate Planning – Definition, Different Strategies, Various Models of Aggregate Planning- Transportation and Graphical Models, Master scheduling, Material Requirement Planning(MRP)- Terminology, Types of Demands, Inputs to MRP, Techniques of MRP, Lot Sizing Methods, Benefits and Drawbacks of MRP, Manufacturing Resources Planning (MRP II), Just in Time (JIT) Philosophy, Kanban System, Calculation of Number of Kanbans, Pull Systems vs. Push Systems, Requirements for Implementation of JIT, JIT Production Process, Benefits of JIT.

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| **UNIT – V:** |
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| Scheduling: Policies, Types of Scheduling, Scheduling Strategies, Scheduling and Loading Guidelines, Forward and Backward Scheduling, Grant Charts, Priority Decision Rules, Flow Shop Scheduling, Job Shop Scheduling, Line of Balance. |
| **Text Books:** |
| 1. Buffa E.S. and Sarin R.K., Modern Production / Operations Management, 8/e, Wiley India Pvt. Ltd., New Delhi, 2009. |
| 2. Joseph G. Monks, Operations Management-Theory and Problems, 3/e, McGraw Hill Education, 1987. |
| **Reference Books:** |
| 1. James L. Riggs, Jim Rigs, Production Systems: Planning, Analysis and Control, 4/e, Wave Land Press, 1992. |
| 2. Chary S.N., Production and Operations Management, 5/e, McGraw Hill Education, 2017. |
| 3. Richard B.Chase, Ravi Shankar, Robert Jacobs F., Operations and Supply Chain Management, 15/e, McGraw Hill Education, 2018 |
| 4. Pannerselvam R., Production and Operations Management, 3/e, PHI Learning Pvt. Ltd., New Delhi, 2012. |
| 5. Steven Nahmias, Tava Lennon Olsen, Production and Operation Analysis: Strategy – Quality – Analytics – Applications, 7/e, Waveland Press Inc., 2015. |
| **Online Learning Resources:** |
| • https://www.vssut.ac.in/lecture_notes/lecture1429900757.pdf |
| • https://lecturenotes.in/subject/100/production-and-operation-management |
| • https://www.studocu.com/in/document/guru-gobind-singh-indraprastha-university/production-operations-management/full-unit-1-lecture-notes-6/3528988 |
| • https://mrcet.com/downloads/digital_notes/ME/III%20year/POM%20NOTES.pdf |
| • https://www.iare.ac.in/sites/default/files/lecture_notes/IARE_OM_NOTES.pdf |

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**JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA**

**B.Tech IV Year I Semester**

**23AME75E – ENERGY AUDITING**

**{OPEN ELECTIVE – IV (E)}**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**Course Objectives:** The objectives of the course are to make the students learn about

- Introduce the concepts of energy scenario and need for energy policy for industries in India.
- Familiarize with the Energy Audit concepts and its approaches.
- Teach the principles and objectives of the Energy management.
- Discuss the Thermal and Electrical Energy management.

**Course Outcomes:** At the end of the course, the students will be able to

CO1: Explain the fundamental aspects of energy scenario in India.

CO2: List the various national and state level energy policies.

CO3: Explain the concepts of energy conservation in boilers.

CO4: Identify the thermal energy components.

CO5: Explain the concepts of supply side methods to minimize supply.

**UNIT – I:**

General Aspects:

Review of energy scenario in India, General Philosophy and need of Energy Audit and Management, Basic elements and measurements - Mass and energy balances – Scope of energy auditing industries - Evaluation of energy conserving opportUNITies, Energy performance contracts, Fuel and Energy substitution, Need for Energy Policy for Industries, National & State level energy Policies.

**UNIT – II:**

Energy Audit Concepts:

Need of Energy audit - Types of energy audit – Energy management (audit) approach - understanding energy costs - Bench marking – Energy performance - Matching energy use to requirement - Maximizing system efficiencies -Optimizing the input energy requirements - Duties and responsibilities of energy auditors- Energy audit instruments - Procedures and Techniques.

**UNIT – III:**

Principles and Objectives of Energy Management:

Design of Energy Management Programmes - Development of energy management systems – Importance - Indian need of Energy Management - Duties of Energy Manager - Preparation and presentation of energy audit reports - Monitoring and targeting, some case study and potential energy savings.

**UNIT – IV:**

Thermal Energy Management:

Energy conservation in boilers - steam turbines and industrial heating systems - Application of FBC - Cogeneration and waste heat recovery -Thermal insulation - Heat exchangers and heat pumps –HVC industries-Building Energy Management.

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**UNIT – V:**

Electrical Energy Management:

Supply side Methods to minimize supply-demand gap- Renovation and modernization of power plants - Reactive power management – HVDC- FACTS - Demand side - Conservation in motors - Pumps and fan systems – Energy efficient motors.

**Text Books:**

1. Murphy, W. R., Energy Management, Elsevier, 2007.
2. Smith, C. B., Energy Management Principles, Pergamum, 2007
3. Handbook of Energy Audit, Sonal Desai, Mcgraw Hill Education Private Ltd.,

**Reference Books:**

1. Turner, W. C., Doty, S. and Truner, W. C., Energy Management Hand book, 7th edition, Fairmont Press, 2009.
2. De, B. K., Energy Management audit & Conservation, 2nd Edition, Vrinda Publication, 2010.
3. Energy Management Handbook – W.C. Turner (John Wiley and Sons, A Wiley a. Interscience publication)
4. Industrial Energy Management and Utilisation –L.C. Witte, P.S. Schmidt, D.R. Brown (Hemisphere Publication, Washington, 1988)
5. Industrial Energy Conservation Manuals, MIT Press, Mass, 1982
6. Energy Conservation guide book Patrick/Patrick/Fardo (Prentice hall1993)

**Online Learning Resources:**

- https://nptel.ac.in/courses/108106022
- https://iare.ac.in/sites/default/files/iare_EAM_lecture%20notes.pdf
- https://beeindia.gov.in/sites/default/files/1Ch3.pdf
- https://sites.google.com/a/venusict.org/energy-conservation-and-management/ntpl-video-links
- https://www.ktunotes.in/ktu-eee-s8-energy-management-and-auditing-notes/

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**B.Tech – Mechanical Engineering**

## INDUSTRIAL ENGINEERING – Minor

| S.No. | Course Code | Course Title | Offered in Semester | Contact Hours per week | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | | L | T | P | |
| 1 | 23AMEM01 | Production Planning and Control | V | 3 | 0 | 0 | 3 |
| 2 | 23AMEM02 | Introduction to Optimization Techniques | VI | 3 | 0 | 0 | 3 |
| 3 | 23AMEM03 | Introduction to Supply Chain Management | VII | 3 | 0 | 0 | 3 |
| 4 | 23AMEM04 | Six sigma and lean manufacturing | VII | 3 | 0 | 0 | 3 |
| 5 | 23AMEM05 | Industry 5.0 for Engineers | VIII | 3 | 0 | 0 | 3 |
| 6 | 23AMEM06 | Industrial Engineering Lab | V | 0 | 0 | 3 | 1.5 |
| 7 | 23AMEM07 | Optimization through MATLAB Lab | VI | 0 | 0 | 3 | 1.5 |
| Total | | | | 15 | 0 | 6 | 18 |

**B.Tech – Mechanical Engineering**

## MACHINE DESIGN – Minor

| S.No. | Course Code | Course Title | Offered in Semester | Contact Hours per week | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | | L | T | P | |
| 1 | 23AMEM08 | Strength of Materials | V | 3 | 0 | 0 | 3 |
| 2 | 23AMEM09 | Kinematics of Machinery | VI | 3 | 0 | 0 | 3 |
| 3 | 23AMEM10 | Design of machine elements | VII | 3 | 0 | 0 | 3 |
| 4 | 23AMEM11 | Product Design | VII | 3 | 0 | 0 | 3 |
| 5 | 23AMEM12 | Introduction to Design for manufacturing | VIII | 3 | 0 | 0 | 3 |
| 6 | 23AMEM13 | Strength of Materials Lab | V | 0 | 0 | 3 | 1.5 |
| 7 | 23AMEM14 | Kinematics of Machinery Lab | VI | 0 | 0 | 3 | 1.5 |
| Total | | | | 15 | 0 | 6 | 18 |

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## B.Tech – Mechanical Engineering

# ADDITIVE MANUFACTURING – Minor

| S.No. | Course Code | Course Title | Offered in Semester | Contact Hours per week | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | | L | T | P | |
| 1 | 23AMEM15 | Introduction to Computer Aided Machine Drawing | V | 3 | 0 | 0 | 3 |
| 2 | 23AMEM16 | CAD | VI | 3 | 0 | 0 | 3 |
| 3 | 23AMEM17 | 3D Printing Materials | V | 3 | 0 | 0 | 3 |
| 4 | 23AMEM18 | 3D Printing Processes | VII | 3 | 0 | 0 | 3 |
| 5 | 23AMEM19 | Applications of Additive Manufacturing | VIII | 3 | 0 | 0 | 3 |
| 6 | 23AMEM20 | CAD Lab | VI | 0 | 0 | 3 | 1.5 |
| 7 | 23AMEM21 | 3D printing Lab | VII | 0 | 0 | 3 | 1.5 |
| Total | | | | 15 | 0 | 6 | 18 |

## B.Tech – Mechanical Engineering

# Robotics and Automation – Minor

| S.No. | Course Code | Course Title | Offered in Semester | Contact Hours per week | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | | L | T | P | |
| 1 | 23AMEM22 | Introduction to Robotics | V | 3 | 0 | 0 | 3 |
| 2 | 23AMEM23 | Industrial Automation. | V | 3 | 0 | 0 | 3 |
| 3 | 23AMEM24 | Hydraulic and Pneumatic Circuits for Robots | VI | 3 | 0 | 0 | 3 |
| 4 | 23AMEM225 | Programming of robot | VII | 3 | 0 | 0 | 3 |
| 5 | 23AMEM26 | Robot Operating Systems | VIII | 3 | 0 | 0 | 3 |
| 6 | 23AMEM27 | Hydraulic and Pneumatic Circuits Lab | VI | 0 | 0 | 3 | 1.5 |
| 7 | 23AMEM28 | Robot Programming Lab | VII | 0 | 0 | 3 | 1.5 |
| Total | | | | 15 | 0 | 6 | 18 |

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|---|---|---|---|---|---|
| **23AMEM01** | **PRODUCTION PLANNING AND CONTROL (Minor degree in Industrial Engineering)** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **3** |

**Course Objectives:**

- To understand the various components and functions of production planning and control such as work study, product planning, process planning, production scheduling, Inventory Control.
- To know the recent trends like manufacturing requirement Planning (MRP II) and Enterprise Resource Planning (ERP).

**UNIT – I:** Introduction:
Objectives and benefits of planning and control-Functions of production control-Types of production-job- batch and continuous-Product development and design-Marketing aspect - Functional aspects-Operational Aspect-Durability and dependability aspect aesthetic aspect. Profit consideration-Standardization, Simplification & specialization- Break even analysis-Economics of a new design.

**UNIT – II:** Work Study
Method study, basic procedure-Selection-Recording of process - Critical analysis, Development - Implementation - Micro motion and memo motion study – work measurement - Techniques of work measurement - Time study - Production study - Work sampling - Synthesis from standard data - Predetermined motion time standards.

**UNIT – III:** Product Planning And Process Planning
Product planning-Extending the original product information-Value Analysis-Problems in lack of product planning-Process planning and routing-Pre requisite information needed for process planning- Steps in process planning-Quantity determination in batch production-Machine capacity, balancing- Analysis of process capabilities in a multi-product system.

**UNIT – IV:** Production Scheduling
Production Control Systems-Loading and scheduling-Master Scheduling-Scheduling rules-Gantt charts-Perpetual loading-Basic scheduling problems - Line of balance – Flow production scheduling- Batch production scheduling-Product sequencing – Production Control systems- Periodic batch control-Material requirement planning kanban – Dispatching-Progress reporting and expediting- Manufacturing lead time-Techniques for aligning completion times and due dates.

**UNIT – V:** Inventory Control And Recent Trends In PPC
Inventory control-Purpose of holding stock-Effect of demand on inventories-Ordering procedures. Two bin system - Ordering cycle system-Determination of Economic order quantity and economic lot size-

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ABC analysis - Recorder Procedure-Introduction to computer integrated production planning systems-elements of Just In Time Systems-Fundamentals of MRP II and ERP.

**Text Books:**

1. James. B. Dilworth," Operations management – Design, Planning and Control for manufacturing and services" McGraw Hill International edition 1992.
2. Martand Telsang, "Industrial Engineering and Production Management", First edition, S. Chand and Company, 2000.

**Reference Books:**

1. Chary. S.N., "Theory and Problems in Production & Operations Management", Tata McGraw Hill, 1995.
2. Elwood S.Buffa, and Rakesh K.Sarin, "Modern Production / Operations Management", 8th Edition John Wiley and Sons, 2000.
3. Jain. K.C. & Aggarwal. L.N., "Production Planning Control and Industrial Management", Khanna Publishers, 1990.
4. Kanishka Bedi, "Production and Operations management", 2nd Edition, Oxford university press, 2007.
5. Melynk, Denzler, "Operations management – A value driven approach" Irwin McGraw hill.

**Online Learning Resources:**

- https://www.youtube.com/watch?v=yYIVumq6sVM
- https://nptel.ac.in/courses/110107141
- https://nptel.ac.in/courses/112107143
- https://www.youtube.com/watch?v=Q7KpUY8spmM

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Explain the basic functions of production control. | L2 |
| CO2 | Illustrate the work sampling and synthesis from standard data. | L2 |
| CO3 | Elaborate the process capabilities in multi-product system. | L3 |
| CO4 | Identify the elements of material requirement planning. | L2 |
| CO5 | Discuss about the ABC Analysis | L4 |

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|---|---|---|---|---|---|
| **23AMEM02** | **INTRODUCTION TO OPTIMIZATION TECHNIQUES (Minor degree in Industrial Engineering)** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **3** |

**Course Objectives:**

- Principles of optimization and its need.
- Learn classical optimization techniques and numerical methods of optimization.
- Numerical optimization techniques for single variable and multi variable non – linear optimization problems.
- Geometry cutting plane method & branch bound method for linear programming problem.
- Formulation of random search methods.

**UNIT I:**

Introduction to Optimization: Mathematical formulation, Classification of optimization problems, Engineering applications of optimization.

Classical Optimization Techniques: Single variable optimization, Constrained and unconstrained multivariable optimization, Direct substitution method, Lagrange's method of multipliers, Karush-Kuhn-Tucker conditions.

**UNIT II**:

Linear Programming: Standard form of an LPP, Geometry of LPP, Simplex algorithm, Two phases of the Simplex method, Revised Simplex method, Dual Simplex method, Assignment problem, Transportation problem.

**UNIT III:**

Nonlinear Programming (One-dimensional): Unimodal function, Unrestricted search, Exhaustive search, Dichotomous search, Interval halving method, Fibonacci method, Golden section method, Quadratic interpolation method, Cubic interpolation method, Newton method, Quasi-Newton method, Secant method.

**UNIT IV:**

Nonlinear Programming (Multidimensional unconstrained): Direct search methods: Random search methods, Grid search method, Univariate method, Hooke and Jeeves method, Powell's method

Indirect search methods: Steepest descent method, Fletcher - Reeves method, Newton's method, Test problems.

**UNIT V:**

Nonlinear Programming (Constrained): Random search methods, Sequential linear programming, Sequential quadratic programming, Transformation techniques, Basic approach of penalty function methods, Interior and exterior penalty function methods, Test problems.

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**Reference Books:**

1 Engineering Optimization Theory and Practice, S.S.Rao, New Age International (P) Ltd Publishers, Third enlarged edition
2 Introduction to Optimum Design, Jasbir S. Arora, McGraw Hill Publication, International edition 1989
3 Optimization for Engineering Design Algorithms and Examples, Kalyanmoy Deb, Prentice Hall, Third reprint 1998

**Online Learning Resources:**

- https://nptel.ac.in/courses/111105039
- https://archive.nptel.ac.in/courses/111/105/111105039/
- https://www.youtube.com/watch?v=aJKuM4U-eYg
- https://onlinecourses.nptel.ac.in/noc21_me10/preview
- https://archive.nptel.ac.in/courses/105/103/105103210/

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Identify optimization methods and algorithms developed for solving various types of optimization problems. | L2 |
| CO2 | Use classical optimization techniques and numerical methods of optimization. | L3 |
| CO3 | Understand and apply numerical optimization techniques for single variable and multi variable non – linear optimization problems. | L1 |
| CO4 | Solve integer programming problem by either geometry cutting plane algorithm or branch band method. | L5 |
| CO5 | Formulate Random search methods and solve it. | L6 |

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| **23AMEM03** | **INTRODUCTION TO SUPPLY CHAIN MANAGEMENT (Minor degree in Industrial Engineering)** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **3** |

**Course Objectives:**

- Explain the basics of supply chain management.
- Familiarize inventory management techniques and models to ensure EOQ batch size under risk management.
- Demonstrate various distribution strategies for shipment of products.
- Focus on evaluating of strategic alliance partners and understanding of RDBMS.

**UNIT - I** Understanding the supply chain:
Understanding the supply chain: What is SCM? Why SCM? The Complexity, Key issues in SCM Logistics network - Introduction, Data Collection, Transportation, Ware house Management, Strategic location of ware houses, Demand forecasting, Role of aggregate planning, MRP, ERP, Managing variability, Key features of Network configuration.

**UNIT - II** Inventory management:
Inventory management: Concepts of Materials Management, Economic lot size model, Effect of Demand uncertainly, Fixed order costs, Variable lead frames, Inventory under certainly & uncertainty, Risk Management

**UNIT - III** Distribution strategies:
Distribution strategies: Introduction, Centralized Vs Decentralized control, Direct shipment, Cross Docking, Push based Vs Pull based supply chain.

**UNIT - IV** Strategic alliances:
Strategic alliances: Third party Logistics (3PL), Retailer – supplier relationship issues, requirements, success & failures, Distributor integration Types & issues.

**UNIT - V** MIS & SCM
MIS & SCM: Relational Data Base Management (RDBMS), System Architecture, Communications, and Implementation of ERP, Decision support systems for SCM: Analytical tools, Presentation tools, Smooth production flow Current issues & directing challenges for future, e-Commerce strategies and world class supply chain management.

**Text books:**

1. Sunil Chopra, Peter Meindl, Supply Chain Management: Strategy, Planning, and Operation, 4/e, Pearson, 2010.
2. David N. Burt, Donald W. Dobler , World Class Supply Management: The Key to Supply Chain Management, 2/e, McGraw-Hill/Irwin, 2003

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**Reference Books:**

1. John Joseph Coyle, Edward J. Bardi, C. John Langley, The Management of Business Logistics: A Supply Chain Perspective, South-Western/Thomson Learning, 2003.
2. Upendra Kachru ,Logistics and Supply Chain Management, Excel Books, 2009.

**Online Learning Resources:**

- https://www.coursera.org/specializations/supply-chain-management
- https://www.investopedia.com/terms/s/scm.asp
- https://www.youtube.com/watch?v=lZPO5RclZEo
- https://www.youtube.com/watch?v=raqi4gjMI.m8
- https://nptel.ac.in/courses/110108056
- https://www.youtube.com/watch?v=Nrl0CtS1m8Y
- https://www.digimat.in/nptel/courses/video/110105141/L01.html
- https://ocw.mit.edu/courses/engineering-systems-division/esd-273j-logistics-and-supply-chain-management-fall-2009/lecture-notes/

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Apply the concepts of supply chain management for demand forecasting. | L3 |
| CO2 | Make use of SCM and inventory management for procurement | L3 |
| CO3 | Analyse the shipment activities and related issues | L4 |
| CO4 | Build third party alliances. | L5 |
| CO5 | Adapt the RDBMS data for communications and analyzing future challenges and understand e-commerce strategies | L6 |

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|---|---|---|---|---|---|
| **23AMEM04** | **SIX SIGMA AND LEAN MANUFACTURING (Minor degree in Industrial Engineering)** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **3** |

**Course Objectives:**

- Introduce the students, the basic concepts of six sigma and lean manufacturing.
- Expose with various quality issues in Inspection.
- Gain Knowledge on quality control and its applications to real time.
- Know the extent of cellular manufacturing and 5S.
- Understand the importance of Quality standards in manufacturing.

**UNIT – I:** Introduction to Six-Sigma

Introduction to Six-Sigma-Probabilistic models-Six Sigma measures -DPMO-Quality level-Reliability function using Six-Sigma-MTTF using Six Sigma-Maintenance free operating period- Availability using Six-Sigma-Point availability-Achieved availability-Operational Availability-Examples.

**UNIT – II:** The Elements of Six Sigma and their Determination

The Elements of Six Sigma and their Determination-The Quality Measurement Techniques: SQC, Six Sigma, Cp and Cpk- The Statistical quality control (SQC) methods-The relationship of control charts and six sigma-The process capability index (Cp)-Six sigma approach-Six sigma and the 1.5 σ shift-The Cpk Approach Versus Six Sigma-Cpk and process average shift- Negative Cpk-Choosing six sigma or Cpk-Setting the process capability index-Examples.

**UNIT – III:** Introduction To Lean Manufacturing:

Introduction To Lean Manufacturing: Conventional Manufacturing versus Lean Manufacturing – Principles of Lean Manufacturing – Basic elements of lean manufacturing – Introduction to LM Tools.

**UNIT – IV:** Cellular Manufacturing, JIT, TPM :

Cellular Manufacturing, JIT, TPM :Cellular Manufacturing – Types of Layout, Principles of Cell layout, Implementation. JIT – Principles of JIT and Implementation of Kanban. TPM – Pillars of TPM, Principles and implementation of TPM.

**UNIT – V:** Set Up Time Reduction, TQM, 5S, VSM 10

Set Up Time Reduction, TQM, 5S, VSM 10

Set up time reduction – Definition, philosophies and reduction approaches. TQM – Principles and implementation. 5S Principles and implementation - Value stream mapping - Procedure and principles.

**Text Books:**

1. U Dinesh Kumar, Crocker, Chitra and Harithe Saranga, Reliability and Six Sigma, Springer Publishers.

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2. Sung H. Park, Six Sigma for Quality and Productivity Promotion, Asian Productivity Organization
3. Sammy G. Shina, Six Sigma for Electronics Design and Manufacturing, McGraw-Hill.

**Reference Books:**

1. Design and Analysis of Lean Production Systems, Ronald G. Askin & Jeffrey B. Goldberg, John Wiley & Sons, 2003.
2. Mikell P. Groover (2002) _Automation, Production Systems and CIM.
3. Rother M. and Shook J, 1999 _Learning to See: Value Stream Mapping to Add Value and Eliminate Muda' , Lean Enterprise Institute, Brookline, MA.

**Online Learning Resources:**

- https://www.youtube.com/watch?v=G_0bl6FHo_c
- https://www.youtube.com/watch?v=SMOQV2CyVQo&list=PL8F39D0611CB7BD3B
- https://www.youtube.com/watch?v=iEM0df_0-0o
- https://www.youtube.com/watch?v=2ePeXePNLrs
- https://www.youtube.com/watch?v=50yrQ5Ub1lc&list=PLLy_2iUCG87B2T7MqpfCr8Vl4A5nwLVm2

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Summarize various techniques that are related to the six-sigma and lean manufacturing. | L2 |
| CO2 | Outline the concepts of cellular manufacturing, JIT and TPM. | L2 |
| CO3 | Illustrate the principles and implementation of 5S techniques. | L2 |
| CO4 | Discus procedure and principles of value stream mapping. | L6 |
| CO5 | Determine the reliability function using six-sigma. | L3 |

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|---|---|---|---|---|---|
| **23AMEM05** | **INDUSTRY 5.0 FOR ENGINEERS (Minor degree in Industrial Engineering)** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **3** |

**Course Objectives:**

- This course is designed to offer learners an introduction to Industry 5.0and its applications.
- Learners will gain deep insights into how smartness is being harnessed from data.
- Learners will understand what needs to be done in order to overcome the challenges.
- To familiarize in Industry 5.0in healthcare services.

**UNIT - I** Introduction to Industry 5.0:
Introduction of Various Industrial Revolutions, Digitalisation and the Networked Economy, Drivers, Enablers, Compelling Forces and Challenges for Industry 5.0, Comparison of Industry 5.0 Factory and Today's Factory, Trends of Industrial Big Data and Predictive Analytics for Smart Business Automation and Transformation Processes.

**UNIT - II** Internet of Things (IoT)
Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services, Smart Manufacturing, Smart Devices and Products, Smart Logistics, Smart Cities, Predictive Analytics.

**UNIT - III** Technologies for enabling Industry 5.0:
Basics of cyber Physical Systems, Process Automations and Collaborative robots, Fundamental to artificial Intelligence, Mobile Computing, Cyber Security, Ethical technology, Responsive and distributed supply chain system, Human-centric and Value-oriented approaches.

**UNIT - IV** 3D printing technologies
3D printing technologies, selection of material and equipment, develop a product using 3D printing in Industry 5.0environment.

**UNIT - V** Technology Implementation and Case Studies
Solar energy sector, Healthcare sector, Maintain records related to education, finance, clean bioenergy generation and Intelligent NextG Wireless Networks. Case studies on CNC/NC automation, In-house, Healthcare services.

**Text Books:**

1. Alasdair Gilchrist, "Industry 5.0: The Industrial Internet of Things", Apress, 2016.
2. Lan Gibson, David W. Rosen and Brent Stucker, "Additive Manufacturing Technologies Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010.

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**Reference Books:**

1. Andreas Gebhardt, "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing", Hanser Publisher, 2011.
2. J. Chanchaichujit, A.Tan, Meng, F., Eaimkhong, S. "Healthcare 5.0Next Generation Processes with the Latest Technologies", Palgrave Pivot, 2019.

**Online Learning Resources:**

- https://nptel.ac.in/courses/106105195
- https://www.edx.org/course/industry-4-0-how-to-revolutionize-your-business
- https://nptel.ac.in/courses/108105102
- https://nptel.ac.in/courses/106105166
- https://www.youtube.com/watch?v=Rqp2n4e_wN4

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Explain fundamentals of Robots. | L2 |
| CO2 | Apply kinematics and differential motions and velocities. | L3 |
| CO3 | Demonstrate control of manipulators. | L2 |
| CO4 | Understand robot vision. | L2 |
| CO5 | Develop robot cell design and programming. | L3 |

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|---|---|---|---|---|---|
| **23AMEM06** | **INDUSTRIAL ENGINEERING LAB (Minor degree in Industrial Engineering)** | **L** | **T** | **P** | **C** |
| | | **0** | **0** | **3** | **1.5** |

**Course Objectives:**

- To design, improve and install integrated systems involving men, materials, and equipment in industrial settings.
- To apply engineering analysis and design using knowledge of mathematics, physical sciences, and industrial systems.
- To address key challenges in manufacturing, distribution, healthcare, utilities, transport, entertainment, and environment using Industrial Engineering tools.
- To equip students with the ability to design, conduct and analyze experiments related to Process Charting, Method Study, and Work Measurement for optimizing human resource utilization.

**List of Experiments:**

1. Preparation of Process Charts for Method Study
2. String diagram
3. Work Measurement - Time study by Stop watch
4. Bolt & Nut assembly, Productivity enhancement experiment
5. Hand-tool dexterity test –Fatigue Measurement
6. Minnesota dexterity test
7. Pyramid Puzzle Burmese test
8. O'Connor Finger Dexterity Test
9. Purdue Peg Board test
10. Simple Assembly Process experiment
11. Segregation/Sorting test using different size bolts, washers (rubber & metal), nuts, screws with one hand and with both hands.
12. Jebsen Taylor Hand function test
13. Study of Control charts for variables
14. Quality Control of Attributes - Sampling experiments
15. Bull-whip effect /Beer Game

**Online Learning Resources:**

- https://nptel.ac.in/courses/112101154
- https://nptel.ac.in/courses/112107263
- https://nptel.ac.in/courses/110104068
- https://www.coursera.org/learn/wharton-operations

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**Course Outcomes:**

| COs | Course Outcome Statement | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | Apply method study tools such as process charts and string diagrams to analyze and improve industrial operations. | L3 |
| CO2 | Conduct work measurement experiments using stopwatch time study and interpret the results for productivity improvement. | L4 |
| CO3 | Evaluate human performance and dexterity using standard industrial tests such as Purdue Peg Board and O'Connor Test. | L5 |
| CO4 | Analyze quality control data using control charts and sampling techniques. | L4 |
| CO5 | Simulate and assess supply chain phenomena like the bullwhip effect using interactive games. | L6 |

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|---|---|---|---|---|---|
| **23AMEM07** | **Optimization Techniques through MATLAB LAB (Minor degree in Industrial Engineering)** | **L** | **T** | **P** | **C** |
| | | **0** | **0** | **3** | **1.5** |

**Course Objectives:**

- To understand the fundamentals of optimization methods and implement them in MATLAB.
- To develop and test MATLAB programs for unconstrained and constrained optimization problems.
- To gain hands-on experience with Optimization Toolbox and Symbolic Math Toolbox.
- To apply numerical methods for solving real-world engineering optimization problems.

**List of Experiments:**

1 Find the maximum and minimum values of the function using the first and second derivatives. Use Symbolic Mathematics Toolbox. Study the functions available in the Optimization Toolbox of MATLAB.

2 Find approximately the optimum point of the given linear programming problem graphically. Find the optimum point and optimum function value of a linear programming problem using the standard functions available in the Optimization Toolbox.

3 Write a program to minimize a non-linear one-dimensional function with no constraints using Unrestricted Search Method. First take the step size fixed and then take accelerated step size. Also, write a program to minimize a non-linear one-dimensional function with no constraints using Exhaustive Search Method.

4 Write a program to minimize a non-linear one-dimensional function with no constraints using Dichotomous Search Method.

5 Write a program to minimize a non-linear one-dimensional function with no constraints using Interval Halving Method.

6 Write a program to minimize a non-linear one-dimensional function with no constraints using Fibonacci Method.

7 Write a program to minimize a non-linear one-dimensional function with no constraints using Golden Section Method.

8 Write a program to minimize a non-linear one-dimensional function with no constraints using Quadratic Interpolation Method. Also, write a program to minimize a non-linear one-dimensional function with no constraints using Cubic interpolation Method.

9 Write a program to minimize a non-linear one-dimensional function with no constraints using Newton's method, Quasi-Newton Method and Secant Method.

10 Write a program to minimize a non-linear multi-dimensional function with no constraints using Univariate Method.

11 Write a program to minimize a non-linear multi-dimensional function with no constraints using Hooke and Jeeves' Method.

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12 Write a program to minimize a non-linear multi-dimensional function with no constraints using Powell's Method.
13 Write a program to minimize a non-linear multi-dimensional function with no constraints using Steepest Descent Method.
14 Write a program to minimize a non-linear multi-dimensional function with no constraints using Fletcher-Reeves Method.
15 Write a program to minimize a non-linear multi-dimensional function with no constraints using Newton's Method.

**Online Learning Resources:**

- https://nptel.ac.in/courses/112105258
- https://nptel.ac.in/courses/103106118
- https://www.coursera.org/learn/matlab
- https://www.youtube.com/user/MATLAB

**Course Outcomes:**

| COs | Course Outcome Statement | Learning Level |
|---|---|---|
| CO1 | Understand the use of MATLAB Optimization Toolbox and Symbolic Math Toolbox. | L2 |
| CO2 | Apply various one-dimensional unconstrained optimization methods using MATLAB programming. | L3 |
| CO3 | Analyze and compare different optimization techniques for efficiency and convergence. | L4 |
| CO4 | Develop MATLAB programs for solving multi-variable unconstrained optimization problems. | L3/L6 |
| CO5 | Evaluate and select appropriate optimization methods for real-world engineering problems. | L5 |

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| **23AMEM08** | **STRENGTH OF MATERIALS (Minor degree in Machine Design)** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **3** |

**Course Objectives:** The objectives of the course are to

- To understand the fundamentals of optimization methods and implement them in MATLAB.
- To develop and test MATLAB programs for unconstrained and constrained optimization problems.
- To gain hands-on experience with Optimization Toolbox and Symbolic Math Toolbox.
- To apply numerical methods for solving real-world engineering optimization problems.

**UNIT– I**

**SIMPLE STRESSES & STRAINS :** Elasticity and plasticity – Types of stresses & strains–Hooke's law – stress – strain diagram for mild steel – Working stress – Factor of safety – Lateral strain, Poisson's ratio & volumetric strain – Bars of varying section – composite bars – Temperature stresses- Complex Stresses - Stresses on an inclined plane under different uniaxial and biaxial stress conditions - Principal planes and principal stresses - Mohr's circle - Relation between elastic constants, Strain energy – Resilience – Gradual, sudden, impact and shock loadings.

**UNIT–II**

**SHEAR FORCE AND BENDING MOMENT :** Definition of beam – Types of beams –Concept of shear force and bending moment – S.F and B.M diagrams for cantilever, simply supported and overhanging beams subjected to point loads, u.d.l, uniformly varying loads and combination of these loads – Point of contra flexure – Relation between S.F., B.M and rate of loading at a section of abeam.

**UNIT–III**

**FLEXURAL STRESSES :** Theory of simple bending, Derivation of bending equation, Determination of bending stresses – section modulus of rectangular, circular, I and T sections– Design of simple beam sections.

**SHEAR STRESSES:** Derivation of formula – Shear stress distribution across various beams sections like rectangular, circular, triangular, I and T sections.

**UNIT–IV**

**DEFLECTION OF BEAMS :** Bending into a circular arc – slope, deflection and radius of curvature – Differential equation for the elastic line of a beam – Double integration and Macaulay's methods – Determination of slope and deflection for cantilever and simply supported beams subjected to point loads, UDL and UVL. Mohr's theorem and Moment area method – application to simple cases.

**TORSION:** Introduction-Derivation- Torsion of Circular shafts- Pure Shear-Transmission of power by circular shafts, Shafts in series, Shafts in parallel.

**UNIT– V**

**THIN AND THICK CYLINDERS:** Thin seamless cylindrical shells – Derivation of formula for longitudinal and circumferential stresses – hoop, longitudinal and volumetric strains – changes in dia, and

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volume of thin cylinders– Thin spherical shells. Wire wound thin cylinders. Lame's equation – cylinders subjected to inside & outside pressures –compound cylinders.

**COLUMNS:**

Buckling and Stability, Columns with Pinned ends, Columns with other support Conditions, Limitations of Euler's Formula, Rankine's Formula.

**Text Books**:

1. GH Ryder, Strength of materials, Palgrave Macmillan publishers India Ltd, 1961.
2. B.C. Punmia, Strength of materials, 10/e, Lakshmi publications Pvt.Ltd, New Delhi, 2018.

**Reference Books**:

1. Gere & Timoshenko, Mechanics of materials, 2/e, CBS publications, 2004.
2. U.C. Jindal, Strength of Materials, 2/e, Pearson Education, 2017.
3. Timoshenko, Strength of Materials Part – I& II, 3/e, CBS Publishers, 2004.
4. Andrew Pytel and Ferdinand L. Singer, Strength of Materials, 4/e, Longman Pulications, 1990.
5. Popov, Mechanics of Solids, 2/e, New Pearson Education, 2015.

**Online Learning Resources:**

- https://onlinecourses.nptel.ac.in/noc19_ce18/preview.
- https://youtube/iY_ypychVNY?si=310htc4ksTQJ8Fv6.
- https://www.youtube.com/watch?v=WEy939Rkd_M&t=2s
- https://www.classcentral.com/course/swayam-strength-of-materials-iitm-184204
- https://www.coursera.org/learn/mechanics-1
- https://www.edx.org/learn/engineering/massachusetts-institute-of-technology-mechanical-behavior-of-materials-part-1-linear-elastic-behavior
- https://archive.nptel.ac.in/courses/112/107/112107146/

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Learn all the methods to analyze beams, columns, frames for normal, shear, and torsion stresses and to solve deflection problems in preparation for the design of such structural components | L1 |
| CO2 | Analyse beams and draw correct and complete shear and bending moment diagrams for beams. | L4 |
| CO3 | Apply the concept of stress and strain to analyze and design structural members and machine parts under axial, shear and bending loads, and moments. | L3 |
| CO4 | Model & Analyze the behavior of basic structural members subjected to various loads | L4 |
| CO5 | Design and analysis of Industrial components like pressure vessels. | L6 |

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|---|---|---|---|---|---|
| **23AMEM09** | **KINEMATICS OF MACHINERY (Minor degree in Machine Design)** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **3** |

**Course Objectives:**

- Introduce various basic mechanisms and their applications.
- Explain importance of degree of freedom.
- Familiarize velocity and acceleration in mechanisms.
- Describe the cams and follower motions.
- Explain the importance of gyroscopic couples.
- Introduce the equation of motion for single degree of freedom system.

**UNIT – I: Simple Mechanisms**

Simple Mechanisms: Classification of mechanisms – Basic kinematic concepts and definitions – Degree of freedom, mobility – Grashof's law, kinematic inversions of four bar chain and slider crank chains- Limit positions – Mechanical advantage- Transmission angle- Description of some common mechanisms- Quick return mechanism, straight line mechanisms – UniversalJoint – Rocker mechanisms.

**UNIT – II: Plane and motion analysis**

Plane and motion analysis: Displacement, velocity and acceleration analysis of simple mechanisms, graphical velocity analysis using instantaneous centers, velocity and acceleration analysis using loop closure equations – kinematic analysis of simple mechanisms – slider crank mechanism dynamics – Coincident points – Coriolis component of acceleration.

**UNIT – III: Gyroscope & Gear Profile**

Gyroscope: Principle of gyroscope, gyroscopic effect in an aeroplane, ship, car and two wheeler, simple problems

Gear Profile: Involute and cycloidal gear profiles, gear parameters, fundamental law of gearing and conjugate action, spur gear contact ratio and interference/undercutting – helical, bevel, worm, rack & pinion gears, epicyclic and regular gear train kinematics.

**UNIT – IV: Balancing of Rotating masses & Cams**

Balancing of Rotating masses: Need for balancing, balancing of single mass and several masses in different planes, using analytical and graphical methods.

Cams: Classification of cams and followers- Terminology and definitions – Displacement diagrams – Uniform velocity, parabolic, simple harmonic and cycloidal motions – derivatives of follower motions- specified contour cams- circular and tangent cams –pressure angle and undercutting.

**UNIT – V: Vibrations & Turning Moment Diagrams and Flywheels**

Vibrations: Introduction, degree of freedom, types of vibrations, free natural vibrations, Newton method and energy method for single degree of freedom. Damped vibrations- under damped, critically damped;

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and over damped systems, forced vibrations with and without damping in single degree of freedom; Vibration isolation and transmissibility.

Turning Moment Diagrams and Flywheels: Turning moment diagrams for steam engine, I.C engine and Multi Cylinder Engine. Crank effort – coefficient of fluctuation of energy, coefficient of fluctuation of speed – Fly Wheel and their design, fly wheels for punching press.

**Text Books:**

1. S.S.Rattan, Theory of Machines, 4/e, Tata Mc-Graw Hill, 2014.
2. P.L.Ballaney, Theory of Machines & Mechanisms, 25/e, Khanna Publishers, Delhi, 2003.

**Reference Books:**

1. F. Haidery, Dynamics of Machines, 5/e, NiraliPrakashan, Pune, 2003.
2. J.E.Shigley, Theory of Machines and Mechanisms, 4/e, Oxford, 2014.
3. G.K.Groover, Mechanical Vibrations, 8/e, Nemchand Bros, 2009.
4. Norton, R.L., Design of Machinery – An Introduction to Synthesis and Analysis of Mechanisms and Machines, 2/e, McGraw Hill, New York, 2000.
5. William T. Thomson, Theory of vibration with applications, 4/e, Englewood Cliffs, N.J.: Prentice Hall, 1993.

**Online Learning Resources:**

- http://acl.digimat.in/nptel/courses/video/112104121/L03.html
- https://www.youtube.com/watch?v=MJeRFzs4oRU
- https://onlinecourses.nptel.ac.in/noc20_me21/preview
- https://nptel.ac.in/courses/112105268
- https://onlinecourses.nptel.ac.in/noc25_me164/preview

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Understand different mechanisms and their inversions. | L2 |
| CO2 | Calculate velocity and acceleration of different links in a mechanism. | L4 |
| CO3 | Apply the effects of gyroscopic couple in ships, aero planes and road vehicles. | L3 |
| CO4 | Evaluate unbalance mass in rotating machines. | L5 |
| CO5 | Analyze free and forced vibrations of single degree freedom systems. | L4 |

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| 23AMEM10 | DESIGN OF MACHINE ELEMENTS (Minor degree in Machine Design) | L | T | P | C |
| | | 3 | 0 | 0 | 3 |

**Course Objectives:**

- Provide an introduction to design of machine elements.
- Familiarize with fundamental approaches to failure prevention for static and dynamic loading.
- Explain design procedures to different types of joints.
- Teach principles of clutches and brakes and design procedures.
- Instruct different types of bearings and design procedures.

**UNIT I: Introduction, Design for Static and Dynamic loads**

**Mechanical Engineering Design:** Design process, design considerations, codes and standards of designation of materials, selection of materials.

**Design for Static Loads:** Modes of failure, design of components subjected to axial, bending, torsional and impact loads. Theories of failure for static loads.

**Design for Dynamic Loads:** Endurance limit, fatigue strength under axial, bending and torsion, stress concentration, notch sensitivity. Types of fluctuating loads, fatigue design for infinite life. Soderberg, Goodman and modified Goodman criterion for fatigue failure. Fatigue design under combined stresses.

**UNIT II: Design of Bolted and Welded Joints**

**Design of Bolted Joints:** Threaded fasteners, preload of bolts, various stresses induced in the bolts. Torque requirement for bolt tightening, gasketed joints and eccentrically loaded bolted joints.

**Welded Joints:** Strength of lap and butt welds, Joints subjected to bending and torsion. Eccentrically loaded welded joints.

**UNIT III: Power transmission Shafts and Couplings**

**Power Transmission Shafts:** Design of shafts subjected to bending, torsion and axial loading. Shafts subjected to fluctuating loads using shock factors.

**Couplings:** Design of flange and bushed pin couplings, universal coupling.

**UNIT IV: Design of Clutches, Brakes and Springs**

**Friction Clutches:** Torque transmitting capacity of disc and centrifugal clutches. Uniform wear theory and uniform pressure theory.

**Brakes:** Different types of brakes. Concept of self-energizing and self-locking of brake. Band and block brakes, disc brakes.

**Springs:** Design of helical compression, tension, torsion and leaf springs.

**UNIT V: Design of Bearings and Gears**

**Design of Sliding Contact Bearings:** Lubrication modes, bearing modulus, McKee's equations, design of journal bearing. Bearing Failures.

**Design of Rolling Contact Bearings:** Static and dynamic load capacity, Stribeck's Equation, equivalent bearing load, load-life relationships, load factor, selection of bearings from manufacturer's catalogue.

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**Design of Spur Gears:** Spur gears, beam strength, Lewis equation, design for dynamic and wear loads.

**Textbooks:**

1 R.L. Norton, Machine Design an Integrated approach, 2/e, Pearson Education, 2004.
2 V.B.Bhandari, Design of Machine Elements, 3/e, Tata McGraw Hill, 2010.
3 Dr. N. C. Pandya &Dr. C. S. Shah, Machine design, 17/e, Charotar Publishing House Pvt. Ltd, 2009.

**Reference Books:**

1. R.K. Jain, Machine Design, Khanna Publications, 1978.
2. J.E. Shigley, Mechanical Engineering Design, 2/e, Tata McGraw Hill, 1986.
3. M.F.Spotts and T.E.Shoup, Design of Machine Elements, 3/e, Prentice Hall (Pearson Education), 2013.
4. K. Mahadevan & K. Balaveera Reddy, Design data handbook, CBS Publications, 4/e, 2018.

**Online Learning Resources:**

- https://www.yumpu.com/en/document/view/18818306/lesson-3-course-name-design-ofmachine-elements-1-nptel
- https://www.digimat.in/nptel/courses/video/112105124/L01.html
- https://dokumen.tips/documents/nptel-design-of-machine-elements-1.html
- https://archive.nptel.ac.in/courses/112/105/112105125/
- https://www.coursera.org/learn/machine-design1

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Estimate safety factors of machine members subjected to static and dynamic loads. | L5 |
| CO2 | Design the fasteners subjected to variety of loads. | L6 |
| CO3 | Select of standard machine elements such as keys, shafts, couplings, springs and bearings. | L1 |
| CO4 | Design of clutches, brakes and springs. | L6 |
| CO5 | Design of bearing and gears. | L6 |

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|---|---|---|---|---|---|
| **23AMEM11** | **PRODUCT DESIGN (Minor degree in Machine Design)** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **3** |

**Course Objectives**

- To Design products creatively while applying engineering design principles
- To Apply principles of human factors, ethics and environmental factorsin product design
- To Work in groups or individually in their pursuit of innovative product design
- To implement value design for optimum product cost.

**UNIT I**

**PRODUCT DEVELOPMENT PROCESS:** General problem solving process - Flow of Work during the process of designing - Activity Planning Timing and scheduling, Planning Project and Product Costs - Effective Organization Structures - Interdisciplinary Cooperation, Leadership and Team behaviour.

**UNIT II**

**TASK CLARIFICATION:** Importance of Task Clarification - Setting up a requirements list - Contents, Format, Identifying the requirements, refining and Extending the requirements, Compiling the requirements list, Examples. Using requirements lists - Updating, Partial requirements lists, Further uses - Practical applications of requirements lists.

**UNIT III**

**CONCEPTUAL DESIGN:** Steps in Conceptual Design. Abstracting to identify the essential problems - Aim of Abstraction, Broadening the problem. Formulation, Identifying the essential problems from the requirements list, Establishing functions structures, Overall function, Breaking a function down into sub-functions. Developing working structures - Searching for working principles, Combining Working Principles, Selecting Working Structures, Practical Application of working structures. Developing Concepts - Firming up into principle solution variants, Evaluating principle solution variants, Practical Applications of working structures. Examples of Conceptual Design - One Handed Household Water Mixing Tap, Impulse - Loading Test Rig.

**UNIT IV**

**EMBODIMENT DESIGN** - Steps of Embodiment Design, Checklist for Embodiment Design

Basic rules of Embodiment Design Principles of Embodiment Design - Principles of Force Transformations, Principles of Division of Tasks, Principles of Self-Help, Principles of Stability and Bi-Stability, Principles of Fault-Free Design Guide for Embodiment Design - General Considerations, Design to allow for expansion, Design to allow for creep and relaxation, Design against Corrosion, Design to minimize wear, Design to Ergonomics, Design for Aesthetics, Design for Production, Design for Assembly, Design for Maintenance, Design for Recycling, Design for Minimum risk, Design to standards. Evaluation of Embodiment Designs.

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**UNIT V**

**MECHANICAL CONNECTIONS, MECHATRONICS AND ADAPTRONICS:** Mechanical Connections - General functions and General Behaviour, Material connections, From Connections, Force connections, Applications. Mechatronics - General Architecture and Terminology, Goals and Limitations, Development of Mechatronic Solution, Examples. Adaptronics - Fundamentals and Terminology, Goals and Limitations, Development of Adaptronics Solutions, Examples.

**TEXT BOOKS:**

1. Engineering Design: G.Paul; W. Beitzetal, Springer International Education 2010.
2. Product Design And Development: Kevin Otto: K. Wood Pearson Education 2013.

**REFERENCE BOOKS:**

1. Product Planning Essentials: Kenith B. Kahu, Yes dee Publishing 2011.
2. Product Design and Development: K.T. Ulrich TMH Publishers 2011.

**Online Learning Resources:**

- https://nptel.ac.in/courses/110104088
- https://www.coursera.org/learn/new-product-development
- https://www.youtube.com/watch?v=K6xFUUz5DRc
- https://nptel.ac.in/courses/112103281
- https://nptel.ac.in/courses/112106138

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Ability to apply knowledge of basic science and engineering fundamentals in the design process. | L3 |
| CO2 | Ability to undertake problem identification, formulation, and solution in the context of product design. | L4 |
| CO3 | Understanding of the principles of sustainable design and development. | L2 |
| CO4 | Understanding of professional and ethical responsibilities and commitment to them during product development. | L2 |
| CO5 | Ability to evaluate and select suitable mechanical, mechatronic, or adaptronic design solutions. | L5 |

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|---|---|---|---|---|---|
| **23AMEM12** | **INTRODUCTION TO DESIGN FOR MANUFACTURING (Minor degree in Machine Design)** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **3** |

**Course Objectives:**

- Explain the product development cycle and manufacturing issues to be considered in design.
- Familiarize manufacturing consideration in cast, forged, and weld components.
- Describe the manufacture of sheet metal components.
- Impart knowledge plastics as substitution to metallic parts.

**UNIT – I:** Introduction
Introduction: Design philosophy-steps in design process-general design rules for manufacturability-basic principles of designing for economical production-creativity in design.
Materials: Selection of materials for design-developments in material technology-criteria for material selection-material selection interrelationship with process selection-process selection charts.

**UNIT – II:** Machining processes:
Overview of various machining processes-general design rules for machining-dimensional tolerance and surface roughness-Design for machining – ease –redesigning of components for machining ease with suitable examples. General design recommendations for machined parts.

**UNIT – III:** Metal Casting and Joining
Metal casting: Appraisal of various casting processes, selection of casting process,-general design considerations for casting-casting tolerance-use of solidification, simulation in casting design-product design rules for sand casting.
Metal joining: Appraisal of various welding processes, factors in design of weldments – general design guidelines-pre and post treatment of welds-effects of thermal stresses in weld joints-design of brazed joints.

**UNIT – IV:** Forging, Extrusion & Sheet metal work
Forging: Design factors for forging – closed die forging design – parting lines of dies – drop forging die design – general design recommendations.
Extrusion & Sheet metal work: Design guide lines extruded sections-design principles for punching, blanking, bending, deep drawing-Keeler Goodman forging line diagram – component design for blanking.

**UNIT – V:** Plastics :
Visco elastic and creep behavior in plastics-design guidelines for plastic components-design considerations for injection moulding – design guidelines for machining and joining of plastics.

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**Text Books:**

1. George E Dieter and Linda Schmidt, Engineering Design, 4/e, McGraw Hill, 2015.
2. A.K.Chitale and R.C.Gupta, Product Design and Manufacturing, 5/e, PHI Learning 2011.
3. David M Anderson, Design for Manufacturability, CRC Press, 2013.

**Reference Books:**

1. James G Bralla, Design For Manufacturability Handbook, 2/e, McGraw Hill, 2004.
2. Dr.P.C.Sharma, Production Technology, S.Chand & Company, 2009.
3. G. Boothroyd, Product Design for Manufacture & Assembly, CRC Press, 3/e, 2010.

**Online Learning Resources:**

- https://nptel.ac.in/courses/112/101/112101005/
- https://www.iare.ac.in/sites/default/files/lecture_notes/DFMA_LECTURE_NOTES.pdf
- https://ocw.mit.edu/courses/mechanical-engineering/2-008-design-and-manufacturing-ii-spring-2004/lecture-notes/
- https://dokumen.tips/documents/design-for-manufacturing-and-assembly-1-lecture-notes-on-design-for-manufacturing.html
- https://www.youtube.com/watch?v=ofmbhbVCUqI
- https://onlinecourses.nptel.ac.in/noc21_me66/preview

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Design mechanical components with economical consideration. | L6 |
| CO2 | Select materials and machining processes. | L6 |
| CO3 | Identify the necessity for redesigning components out of manufacturing considerations. | L3 |
| CO4 | Consider the manufacturing considerations while designing cast, forged weld and sheet metal components. | L3 |
| CO5 | Design plastic parts with manufacturing considerations. | L6 |

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|---|---|---|---|---|---|
| **23AMEM13** | **STRENGTH OF MATERIALS LAB (Minor degree in Machine Design)** | **L** | **T** | **P** | **C** |
| | | **0** | **0** | **3** | **1.5** |

**Course Objectives:**

- Evaluate the values of yield stress, ultimate stress, and bending stress using standard tensile and bending tests.
- Conduct a torsion test to determine the modulus of rigidity of the specimen.
- Compare Rockwell, Brinell, and Vickers hardness tests and determine hardness.
- Examine the stiffness of springs (open and closed coil) and classify them.
- Analyze the microstructure and mechanical behavior of ferrous and non-ferrous alloy specimens.

**NOTE: Any 6 experiments from each section A and B.**

**A) MECHANICS OF SOLIDS LAB:**

1. Tensile Test – Evaluate stress-strain behavior, yield point, and ultimate tensile strength.
2. Bending Test on
    a) Simply Supported Beam
    b) Cantilever Beam
3. Torsion Test – Determine modulus of rigidity.
4. Hardness Tests
    a) Brinell's Hardness Test
    b) Rockwell Hardness Test
    c) Vickers Hardness Test
5. Test on Springs – Determine stiffness of open coil and closed coil springs.
6. Impact Tests
    a) Charpy Test
    b) Izod Test
7. Punch Shear Test – Shear strength of sheet metal.
8. Liquid Penetration Test – Surface crack detection.

**Online Learning Resources:**

- https://nptel.ac.in/courses/112106293
- https://nptel.ac.in/courses/112105124
- https://nptel.ac.in/courses/113107113
- https://vlab.co.in/broad-area-mechanical-engineering

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**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Evaluate mechanical properties (yield, ultimate, bending stresses) using tensile and bending tests. | **L5** |
| CO2 | Determine the modulus of rigidity using torsion testing of materials. | **L3** |
| CO3 | Compare and justify the use of different hardness testing methods and measure hardness. | **L4** |
| CO4 | Conduct spring testing and evaluate stiffness properties of various types of springs. | **L4** |
| CO5 | Examine microstructures and interpret mechanical behavior of ferrous and non-ferrous alloys. | **L5** |

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|---|---|---|---|---|---|
| **23AMEM14** | **KINEMATICS OF MACHINERY LAB (Minor degree in Machine Design)** | **L** | **T** | **P** | **C** |
| | | **0** | **0** | **3** | **1.5** |

**Course Objectives:**

- To familiarize students with the working and applications of various types of governors.
- To study static and dynamic balancing using specialized equipment.
- To conduct analysis using cam analyzer and gyroscopic devices.
- To understand and analyze gear mechanisms, four-bar linkages, and velocity/acceleration diagrams.

**List of experiments:**

1. Study of kinematic links, pairs, chains, and basic mechanisms.
2. Demonstration of Whitworth Quick Return, Reciprocating Engine, and Oscillating Engine Mechanisms.
3. Inversions of Four-bar Linkage Mechanisms.
4. Study of various gears (helical, cross-helical, worm, bevel) and gear tooth profiles (involute, cycloidal); interference conditions.
5. Determination of gyroscopic couple using Motorized Gyroscope.
6. Performance test on dead weight type governor – sensitivity and stability.
7. Performance test on spring-controlled governor – sensitivity and stability.
8. Static and dynamic balancing experiment.
9. Cam analysis using cam profile apparatus.
10. Determination of whirling speed of shaft (both theoretically and experimentally).
11. Velocity analysis using:
    a) Relative velocity method
    b) Instantaneous center method
    (Minimum 2 problems each)
12. Acceleration analysis using:
    a) Coriolis acceleration
    b) Klein, Ritterhaus, and Modified Klein constructions
    (Minimum 2 problems + 1 shortcut method problem)

**Online Learning Resources:**

- https://nptel.ac.in/courses/112105125
- https://nptel.ac.in/courses/112107080
- https://vlab.co.in/broad-area-mechanical-engineering
- https://nptel.ac.in/courses/115103115

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**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Analyze kinematic mechanisms (links, pairs, chains) and their inversions. | **L4** |
| CO2 | Perform experiments on various governors and evaluate their stability and sensitivity. | **L5** |
| CO3 | Conduct gyroscopic and balancing experiments to study dynamic behavior. | **L3** |
| CO4 | Analyze and interpret gear tooth profiles, interference conditions, and cam profiles. | **L4** |
| CO5 | Solve problems on velocity and acceleration of mechanisms using graphical and analytical methods. | **L3** |

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|---|---|---|---|---|---|
| **23AMEM15** | **INTRODUCTION TO COMPUTER-AIDED MACHINE DRAWING (Minor degree in Additive Manufacturing)** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **3** |

**Course Objectives:**

- Introduce conventional representations of material and machine components.
- Train to use software for 2D and 3D modeling.
- Familiarize with thread profiles, riveted, welded and key joints.
- Teach solid modeling of machine parts and their sections.
- Explain creation of 2D and 3D assembly drawings and Familiarize with limits, fits, and tolerances in mating components

**The following are to be done by any 2D software package**

**Conventional representation of materials and components:**

**Detachable joints:** Drawing of thread profiles, hexagonal and square-headed bolts and nuts, bolted joint with washer and locknut, stud joint, screw joint and foundation bolts.

**Riveted joints:** Drawing of rivet, lap joint, butt joint with single strap, single riveted, double riveted double strap joints.

**Welded joints:** Lap joint and T joint with fillet, butt joint with conventions.

**Keys:** Taper key, sunk taper key, round key, saddle key, feather key, woodruff key.

**Couplings:** rigid – Muff, flange; flexible – bushed pin-type flange coupling, universal coupling, Oldham's' coupling.

**The following exercises are to be done by any 3D software package:**

**Sectional views:**

Creating solid models of complex machine parts and sectional views.

**Assembly drawings: (Any four of the following using solid model software)**

Lathe tool post, tool head of shaping machine, tail-stock, machine vice, gate valve, carburetor, piston, connecting rod, eccentric, screw jack, plumber block, axle bearing, pipe vice, clamping device, Geneva cam, universal coupling.

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**Production drawing:**
Representation of limits, fits and tolerances for mating parts. Use any four parts of above assembly drawings and prepare manufacturing drawing with dimensional and geometric tolerances.

**Textbooks:**
1 Machine Drawing by K.L.Narayana, P.Kannaiah and K.Venkat Reddy, New Age International Publishers, 3/e, 2014
2 Machine drawing by N.Sideshwar, P. Kannaiah, V.V.S.Sastry, TMH Publishers. 2014.

**Reference Books:**
1. Cecil Jensen, Jay Helsel and Donald D.Voisinet, Computer Aided Engineering Drawing, Tata McGraw-Hill, NY, 2000.
2. James Barclay, Brain Griffiths, Engineering Drawing for Manufacture, Kogan Page Science, 2003.
3. N.D.Bhatt, Machine Drawing, Charotar Publishers, 50/e, 2014.

**Online Learning Resources:**
- https://eeedocs.wordpress.com/wp-content/uploads/2014/02/machinedrawing.pdf
- https://archive.nptel.ac.in/courses/112/105/112105294/
- https://www.edx.org/learn/engineering/dassault-systemes-solidworks-solidworks-cad-fundamentals?index=product&queryID=c90b35a82a6ef58b0d6f89679c63f6a1&position=2&linked_from=autocomplete&c=autocomplete
- https://www.youtube.com/watch?v=0bQkS3_3Fq4

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Interpret conventional representation of machine components, materials, and standard joints in engineering drawings. | L1 |
| CO2 | Construct 2D drawings of detachable, riveted, welded joints and couplings using standard drawing conventions. | L2 |
| CO3 | Model 3D components and generate sectional views of machine elements using CAD software. | L2 |
| CO4 | Assemble machine components in 3D software and generate assembly drawings with sections. | L3 |
| CO5 | Develop production drawings incorporating limits, fits, and geometric tolerances for real-world manufacturing. | L3 |

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|---|---|---|---|---|---|
| **23AMEM16** | **CAD**<br>**(Minor degree in Additive Manufacturing)** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **3** |

**Course Objectives:**

- Introduce the fundamentals of CAD tools, hardware components, and display technologies used in computer graphics.
- Explain the principles of 2D and 3D geometric modeling using curves and surfaces with parametric and synthetic formulations.
- Familiarize students with solid modeling techniques and their applications in design and manufacturing.
- Enable students to apply geometric transformations and understand the concepts of projections and coordinate systems in CAD.
- Impart foundational knowledge of Finite Element Analysis (FEA) and its application in solving simple 1D structural problems using the stiffness method.

**UNIT I: Introduction:**
A typical product cycle, CAD tools for the design process of product cycle, CAD / CAM system evaluation criteria, Input / Output devices; Graphics Displays: Refresh display, DVST, Raster display, pixel value and lookup table, estimation of graphical memory, LCD, LED fundamentals. Concept of Coordinate Systems: Working Coordinate System, Model Coordinate System, Screen Coordinate System. Line and Curve generation algorithm: DDA, Bresenham's algorithms. Graphics exchange standards and Database management systems.

**UNIT II: Curves and Surfaces:**
Parametric representation of lines: Locating a point on a line, parallel lines, perpendicular lines, distance of a point, Intersection of lines. Parametric representation of circle, Ellipse, parabola and hyperbola. Synthetic Curves: Concept of continuity, Cubic Spline: equation, properties and blending. Bezier Curve: equations, properties; Properties and advantages of B-Splines and NURBS. Various types of surfaces along with their typical applications.

**UNIT III: Mathematical representation of solids:** Geometry and Topology, Comparison of wireframe, surface and solid models, Properties of solid model, properties of representation schemes, Concept of Half-spaces, Boolean operations. Schemes: B-rep, CSG, Sweep representation, ASM, Primitive instancing, Cell Decomposition and Octree encoding.

**UNIT – IV: Geometric Transformations:** Homogeneous representation; Translation, Scaling, Reflection, Rotation, Shearing in 2D and 3D; Orthographic and perspective projections. Window to View-port transformation.

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**UNIT – V: Finite Element Analysis:** Review of stress-strain relation and generalized Hooke's Law, Plane stress and Plane strain conditions; Concept of Total Potential Energy; Basic procedure for solving a problem using Finite Element Analysis.

1-D Analysis: Concept of Shape function and natural coordinates, strain - displacement matrix, derivation of stiffness matrix for structural problems, properties of stiffness matrix. 1-D structural problems with elimination and penalty approaches.

**Reference Books:**

1. Ibrahim Zeid, CAD/CAM: Theory and Practice — 1/e, published by McGraw-Hill in 1991.
2. Donald D. Hearn & M. Pauline Baker, Computer Graphics — Common references point to the 2/e of the C Version, published by Prentice Hall in 1996.
3. Tirupathi R. Chandrupatla & Ashok D. Belegundu, Introduction to Finite Elements in Engineering, 4/e, published by Pearson in 2011.
4. Daryl L. Logan, A First Course in the Finite Element Method, 4/e, published by Cengage in 2016.

**Online Learning Resources:**

- https://nptel.ac.in/courses/106/106/106106090/
- https://archive.nptel.ac.in/courses/112/102/112102101/
- https://archive.nptel.ac.in/courses/112/107/112107290/
- https://nptel.ac.in/courses/112/105/112105859/

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Explain CAD tools, input/output devices, graphics displays, coordinate systems, and curve generation algorithms. | **L1** |
| CO2 | Construct and analyze various curves and surfaces using parametric and synthetic formulations including B-Splines/NURBS. | **L2** |
| CO3 | Differentiate and apply solid modeling techniques using B-rep, CSG, Sweep, and Octree methods. | **L2** |
| CO4 | Perform 2D and 3D geometric transformations and graphical projections. | **L2** |
| CO5 | Analyze 1D structural problems using finite element methods with shape functions and stiffness matrices. | **L3** |

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|---|---|---|---|---|---|
| **23AMEM17** | **3D PRINTING MATERIALS (Minor degree in Additive Manufacturing)** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **3** |

**Course Objectives:**

- Explain the need of 3D Printing Technology.
- Familiarize manufacturing of polymer components.
- Describe the manufacture of products through powder metallurgy.
- Impart knowledge on various material characterization techniques.

**UNIT – I:** Introduction
Need for AM, Historical Development, Fundamentals of AM, AM Process Chain, Advantages and Limitations of AM, Classification of AM Systems, Materials used in AM.

**UNIT – II:** Polymers basic concepts
Polymers Basic Concepts: Introduction to Polymers used for additive manufacturing: polyamide, PF resin, polyesters etc. Classification of polymers, Concept of functionality, Polydispersity and Molecular weight [MW], Molecular Weight Distribution [MWD].
Polymer Processing: Methods of spinning for additive manufacturing: Wet spinning, Dry spinning. Biopolymers, Compatibility issues with polymers. Moulding and casting of polymers, Polymer processing techniques.

**UNIT – III:** Powder Metallurgy
Powder Metallurgy Basic Concepts: Introduction and History of Powder Metallurgy (PM), Present and Future Trends of PM, Different Mechanical and Chemical methods, Atomization of Powder, other emerging processes.

**UNIT – IV:** Powder Shaping and Sintering
Powder Shaping: Particle Packing Modifications, Lubricants & Binders, Powder Compaction & Process Variables, Pressure & Density Distribution during Compaction, isostatic pressing, Injection Moulding, Powder Extrusion, Slip Casting, Tape Casting.
Sintering: Theory of Sintering, Sintering of Single & Mixed Phase Powder, Liquid Phase Sintering Modern Sintering Techniques, Physical & Mechanical Properties Evaluation, Structure-Property Correlation Study, Modern Sintering techniques, Defects Analysis of Sintered Components.

**UNIT – V:** Introduction to Characterization
Characterization Techniques: Particle Size & Shape Distribution, Electron Microscopy of Powder, Interparticle Friction, Compression ability, Powder Structure, Chemical Characterization. Microstructures of Powder by Different techniques characterization methods -BET surface area analyzer, Atomic force Microscopy (AFM), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), X-ray Diffraction (XRD), Small Angle X-ray Scattering (SAXS) and High Power X-ray.

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**Text Books:**

1. Chee Kai Chua, Kah Fai Leong, "3D Printing and Additive Manufacturing Principles and Applications" 5/e, World Scientific.
2. G Odian Principles of Polymerization, Wiley Inerscience John Wiley and Sons, 4/e, 2005.

**Reference Books:**

1. Mark James Jackson, Microfabrication and Nanomanufacturing, CRC Press, 2005.
2. Powder Metallurgy Technology, Cambridge International Science Publishing, 2002.
3. P. C. Angelo and R. Subramanian: Powder Metallurgy- Science, Technology and Applications, PHI, New Delhi, 2008.
4. Ray F. Egerton, Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM, Springer, 2005.

**Online Learning Resources:**

- https://nptel.ac.in/courses/112104265
- https://nptel.ac.in/courses/112103306
- https://nptel.ac.in/courses/108108115
- https://onlinecourses.nptel.ac.in/noc20_mg70/preview
- https://nptel.ac.in/courses/116102052

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Development mechanical components with powder metallurgy technique. | L6 |
| CO2 | Select materials for Additive Manufacturing. | L4 |
| CO3 | Explain the concept of material characterization. | L3 |
| CO4 | Understand the concepts of powder shaping and sintering. | L1 |
| CO5 | Use the Material Characterization Techniques. | L4 |

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|---|---|---|---|---|---|
| **23AMEM18** | **3D PRINTING PROCESSES (Minor degree in Additive Manufacturing)** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **3** |

**Course Objectives:**

- Familiarize of additive manufacturing / rapid prototyping and its applications in various fields.
- Impart reverse engineering techniques.
- Explain different processes available in additive manufacturing.
- Bring awareness on mechanical properties of materials and geometric issues related to additive manufacturing applications.

**UNIT – I:** Introduction to Additive Manufacturing (AM) Systems:
History and Development of AM, Need of AM, Difference between AM and CNC, Classification of AM Processes: Based on Layering Techniques, Raw Materials and Energy Sources, AM Process Chain, Benefits and Applications of AM, Representation of 3D model in STL format, RP data formats: SLC, CLI, RPI, LEAF, IGES, CT, STEP, HP/GL.

**UNIT – II:** CAD & Reverse Engineering:
Basic Concept, Digitization techniques, Model Reconstruction, Data Processing for Additive Manufacturing Technology: CAD model preparation, Part Orientation and support generation, Model Slicing, Tool path Generation, Software's for Additive Manufacturing Technology: MIMICS, MAGICS. Reverse Engineering (RE) –Meaning, Use, RE – The Generic Process, Phase of RE Scanning, Contact Scanners, Noncontact Scanners, Point Processing, Application Geometric Model, Development.

**UNIT – III:** Solid and Liquid Based AM Systems:
Stereolithography (SLA): Principle, Process, Materials, Advantages, Limitations and Applications. Solid Ground Curing (SGC): Principle, Process, Materials, Advantages, Limitations, Applications. Fusion Deposition Modeling (FDM): Principle, Process, Materials, Advantages, Limitations, Applications. Laminated Object Manufacturing (LOM): Principle, Process, Materials, Advantages, Limitations, Applications.

**UNIT – IV:** Powder Based AM Systems:
Principle and Process of Selective Laser Sintering (SLS), Advantages, Limitations and Applications of SLS, Principle and Process of Laser Engineered Net Shaping (LENS), Advantages, Limitations and Applications of LENS, Principle and Process of Electron Beam Melting (EBM), Advantages, Limitations and Applications of EBM.

**UNIT – V:** Other Additive Manufacturing Systems:
Three Dimensional Printing (3DP): Principle, Process, Advantages, Limitations and Applications. Ballistic Particle Manufacturing (BPM): Principle, Process, Advantages, Limitations, Applications. Shape Deposition Manufacturing (SDM): Principle, Process, Advantages, Limitations, Applications.

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**Text Books:**

1. Ian Gibson, David W. Rosen, Brent Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, 1/e Springer, 2010.
2. Chua C.K., Leong K.F. and Lim C.S., Rapid Prototyping: Principles and Applications, 2/e World Scientific Publishers, 2003.
3. Liou W. Liou, Frank W., Liou, Rapid Prototyping and Engineering Applications: A Tool Box for Prototype Development, CRC Press, 2007.

**Reference Books:**

1. Pham D.T. and Dimov S.S., Rapid Manufacturing; The Technologies and Application of RPT and Rapid Tooling, Springer, London 2001.
2. Gebhardt A., Rapid prototyping, Hanser Gardener Publications, 2003.
3. Hilton P.D. and Jacobs P.F., Rapid Tooling: Technologies and Industrial Applications, CRC Press, 2005.
4. Rafiq Noorani, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons, 2006.

**Online Learning Resources:**

- https://www.hubs.com/knowledge-base/introduction-fdm-3d-printing/
- https://slideplayer.com/slide/6927137/
- https://www.mdpi.com/2073-4360/12/6/1334
- https://www.centropiaggio.unipi.it/sites/default/files/course/material/2013-11-29%20-%20FDM.pdf
- https://lecturenotes.in/subject/197

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Demonstrate various additive manufacturing and rapid prototyping techniques applications. | L4 |
| CO2 | Describe different additive manufacturing processes. | L3 |
| CO3 | Apply methods in rapid prototyping. | L2 |
| CO4 | Use powder based AM system. | L3 |
| CO5 | Model 3D printing using SDM and BPM methods. | L6 |

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| **23AMEM19** | **APPLICATIONS OF ADDITIVE MANUFACTURING (Minor degree in Additive Manufacturing)** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **3** |

**Course Objectives:**

- Explain the typical application areas of additive manufacturing.
- Familiarize with the applications of 3D printing in Design and Engineering area.
- Describe the concepts of manufacturing of bio-medical implants.
- Impart knowledge on Applications in Automotive, Civil and other fields.

**UNIT – I:** Typical application areas of Additive Manufacturing
Finishing Processes- Cutting Processes, Sand-Blasting and Polishing, Coating, Painting.

**UNIT – II:** Applications in Design and Engineering
Applications in Design: CAD Model Verification, Visualizing Objects, Proof of Concept, Marketing and Commercial Applications.

Applications in Engineering Analysis and Planning: Scaling, Form and Fit, Flow Analysis, Stress Analysis, Mock-Up Parts, Pre-Production Parts, Diagnostic and Surgical Operation Planning, Design and Fabrication of Custom Prosthesis and Implant.

**UNIT – III:** Applications in Manufacturing and Tooling
Classification of rapid tooling, Direct Soft Tooling, Indirect Soft Tooling, Direct Hard Tooling.

**UNIT – IV:** Applications in Bio-medical and Aerospace
Operation Planning for Cancerous Brain Tumor Surgery, Planning Reconstructive Surgery with RP Technology, Craniofacial Reconstructive Surgery Planning, Biopsy Needle Housing, Knee Implants, Scaffolds for Tissue Engineering, Customized Tracheobronchial Stents, Inter-Vertebral Spacers, Cranium Implant, Design Verification of an Airline Electrical Generator, Engine Components for Fanjet Engine, Fabrication of Flight-Certified Production Castings.

**UNIT – V:** Applications in Automotive, Civil and other fields
Prototyping Complex Gearbox Housing for Design Verification, Prototyping Advanced Driver Control System with Stereolithography, Creating Cast Metal Engine Block with RP Process, Using Stereolithography to Produce Production Tooling, Civil engineering- 3D printing in house construction, Development of Contour Crafting Process, Building Disaster Relief Shelters, Metal Frames For Solid Structures, other fields- Coin industry, Jewelry Industry, tableware industry.

**Text Books:**

1. Chee Kai Chua, Kah Fai Leong, "3D Printing and Additive Manufacturing Principles and Applications" 5/e, World Scientific.
2. Liou W. Liou, Frank W., Liou, Rapid Prototyping and Engineering Applications: A Tool Box for Prototype Development, CRC Press, 2007.

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**Reference Books:**

1. Pham D.T. and Dimov S.S., Rapid Manufacturing; The Technologies and Application of RPT and Rapid Tooling, Springer, London 2001.
2. Gebhardt A., Rapid prototyping, Hanser Gardener Publications, 2003.
3. Hilton P.D. and Jacobs P.F., Rapid Tooling: Technologies and Industrial Applications, CRC Press, 2005.
2. RafiqNoorani, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons, 2006.

**Online Learning Resources:**

- https://www.mdpi.com/2073-4360/12/6/1334
- https://www.centropiaggio.unipi.it/sites/default/files/course/material/2013-11-29%20-%20FDM.pdf
- https://lecturenotes.in/subject/197
- https://www.cet.edu.in/noticefiles/258_Lecture%20Notes%20on%20RP-ilovepdf-compressed.pdf

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Design CAD model and verification of CAD model | L6 |
| CO2 | Select type of 3D printing technology for different applications. | L2 |
| CO3 | Identify the various applications of 3D printing in manufacturing and aerospace. | L3 |
| CO4 | Explain the various Applications of 3D printing in Automotive, Civil and other fields. | L2 |
| CO5 | List the various applications of 3D printing technology. | L1 |

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|---|---|---|---|---|---|
| **23AMEM20** | **CAD LABORATORY (Minor degree in Additive Manufacturing)** | **L** | **T** | **P** | **C** |
| | | **0** | **0** | **3** | **1.5** |

**Course Objectives:**

- To familiarize students with fundamental CAD tools for 2D and 3D modeling.
- To train students in geometric modeling techniques and solid modeling.
- To provide hands-on experience with assembly modeling and surface modeling.
- To introduce students to the basics of Finite Element Analysis (FEA) using CAD-integrated platforms.

**List of Experiments:**

1. Prepare a program for plotting lines and curves using algorithms learned (DDA, Bresenham's, etc.).
2. Introductory exercise for 3D modeling.
3. Exercise for advanced 3D modeling.
4. Exercise for 3D editing options – Any 2 models.
5. Exercise for Assembly modeling – Any 2 models.
6. Exercise for Surface modeling – Any 2 models.
7. Introductory exercise for Finite Element Analysis (FEA).
8. Exercise for FEA of 1D structural problems.

**Online Learning Resources:**

- https://academy.autodesk.com/
- https://www.solidworks.com/edu
- https://www.ansys.com/academic/students
- https://nptel.ac.in/

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Review and train in CAD modeling. | L2 |
| CO2 | Design a part or assembly of parts using Computer-Aided Design software. | L6 |
| CO3 | Apply top-down design principles to model a design. | L4 |

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|---|---|---|---|---|---|
| **23AMEM21** | **3D PRINTING PRACTICE LAB (Minor degree in Additive Manufacturing)** | **L** | **T** | **P** | **C** |
| | | **0** | **0** | **3** | **1.5** |

**Course Objectives:**

- To understand the working of 3DPrinter and its parts
- To simulate the 3Dprinting processes
- To create 3D objects using design software.
- To analyse effect on time by change in the process parameters
- To identify the defects on the 3Dprinted components.

1. Introduction to Prototyping, working of 3D Printer, Types of 3D printing Machines
2. Simulation of Cartesian 3D Printer Machine
3. Simulation of Stereolithography, Fused Deposition Modelling, Selective Laser Sintering (Metal and Non-Metal), Laminated Object Manufacturing, Powder Binding/Jetting Processes
4. Simulation of Pre-Processing and Post-processing in Additive Manufacturing
5. Modelling of a component and Conversion of STL format using CAD Packages.
   a. Exercise – 1: Engineering Components (Gears, bearings, couplings, pulleys etc.,)
   b. Exercise – 2: Non Engineering Components (Integration of 2D images/logos to develop the customized parts like mobile stand, key chains, photo frames etc.,)
6. Introduction to slicing softwares (Ultimaker Cura, Slicer, PrusaSlicer, OctoPrint etc.,), use of transformation tools and process parameters like layer thickness, Orientation and infill.
7. Build time analysis by changing the machine and process parameters using slicing software
8. Slicing and 3d printing of engineering and non-engineering components by varying
   a. Layer thickness
   b. Orientation
   c. Infill density
9. Study on effect of different materials like ABS, PLA, Resin etc., and dimensional accuracy.
10. Identify the defects in 3D printed components made by varying layer thickness, orientation and infill.

**Text books:**

1. Ian Gibson, David W.Rosen, Brent Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, 1/e, Springer, 2010.
2. Chua C.K, Leong K.F and Lim C.S, Rapid Prototyping: Principles and Applications, 2/e, World Scientific Publishers, 2003.

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**Online Learning Resources:**

- https://3dp-dei.vlabs.ac.in/List of experiments.html
- https://virtual-labs.github.io/exp-simulation-cartesian-system-dei/theory.html
- https://www.hubs.com/knowledge-base/introduction-fdm-3d-printing/
- https://www.slideplayer.com/slide/6927137/
- https://www.mdpi.com/2073-4360/12/6/1334
- https://www.centropiaggio.unipi.it/sites/default/files/course/material/2013-11-29%20-%20FDM.pdf
- https://lecturenotes.in/subject/197
- https://www.cet.edu.in/noticefiles/258_Lecture%20Notes%20on%20RP-ilovepdf-compressed.pdf
- http://www.vssut.ac.in/lecture_notes/lecture1517967201.pdf
- https://www.youtube.com/watch?v=NkC8TNts4B4

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Explain different types of 3D Printing techniques | L2 |
| CO2 | Identify parameter for Fused Deposition Modelling process. | L1 |
| CO3 | Determine effective use of PLA and ABS materials for 3D Printing | L3 |
| CO4 | Apply Principles of mathematics to evaluate the volume of material required | L4 |

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|---|---|---|---|---|---|
| **23AMEM22** | **INTRODUCTION TO ROBOTICS (Minor degree in Robotics and Automation)** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **3** |

**Course Objectives:**

- Learn the fundamental concepts of industrial robotic technology.
- Apply the basic mathematics to calculate kinematic and dynamic forces in robot manipulator.
- Understand the robot controlling and programming methods.
- Describe concept of robot vision system.

**UNIT – I: Fundamentals of Robots**

Introduction, definition, classification and history of robotics, robot characteristics and precision of motion, advantages, disadvantages and applications of robots. Introduction to matrix representation of a point in a space a vector in space, a frame in space, Homogeneous transformation matrices, representation of a pure translation, pure rotation about an axis.

**UNIT – II: Kinematics, Differential Motions and Velocities of Robot**

Kinematics of robot: Forward and inverse kinematics of robots- forward and inverse kinematic equations for position and orientation, Denavit-Hartenberg(D-H) representation of forward kinematic equations of robots, the inverse kinematic of robots, degeneracy and dexterity, simple problems with D-H representation.

Differential motions and Velocities: Introduction, differential relationship, Jacobian, differential motions of a frame-translations, rotation, rotating about a general axis, differential transformations of a frame. Differential changes between frames, differential motions of a robot and its hand frame, calculation of Jacobian, relation between Jacobian and the differential operator, Inverse Jacobian.

**UNIT – III: Control of Manipulators**

Open- and close-loop control, the manipulator control problem, linear control schemes, characteristics of second-order linear systems, linear second-order SISO model of a manipulator joint, joint actuators, partitioned PD control scheme, PID control Scheme, computer Torque control, force control of robotic manipulators, description of force-control tasks, force control strategies, hybrid position/force control, impedance force/torque control.

**UNIT – IV: Robot Vision**

Introduction, architecture of robotic vision system, image processing, image acquisition camera, image enhancement, image segmentation, imaging transformation, Camera transformation and calibrations, industrial applications of robot vision.

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**UNIT – V: Robot Cell Design and Programming**

Robot cell layouts – Robot centered cell, In – line robot cell, considerations in work cell design, work cell control, inter locks, error detection, work cell controller. Methods of robot programming, WAIT, SIGNAL, and DELAY commands, Robotic languages, VAL system.

**Text Books:**

1. Mikell P. Groover and Mitchell Weiss, Roger N. Nagel,Nicholas G.Odrey , Industrial Robotics — Mc Graw Hill, 1986.
2. R K Mittal and I J Nagrath, Robotics and control, Illustrated Edition, Tata McGraw Hill India 2003.

**Reference Books:**

1. Saeed B. Niku, Introduction to Robotics – Analysis, System, Applications, 2nd Edition, John Wiley & Sons, 2010.
2. H. Asada and J.J.E. Slotine, Robot Analysis and Control, 1st Edition Wiley- Interscience, 1986.
3. Robert J. Schillin, Fundamentals of Robotics: Analysis and control, Prentice-Hall Of India Pvt. Limited, 1996.
4. Mohsen shahinpoor, A robot Engineering text book, Harper & Row Publishers, 1987.
5. John.J.Craig Addison, Introduction to Robotics: Mechanics and Control, Wesley, 1999.
6. K.S. FU, R.C. Gonzalez and C.S.G Lee, Robotics: Control, sensing, vision, and intelligence. Mc Graw Hill, 1987.
7. Richard D. Klafter, Thomas Robotic Engineering an integrated approach, PHI publications 1988.

**Online Learning Resources:**

- https://nptel.ac.in/courses/108105088
- https://nptel.ac.in/courses/108105063
- https://nptel.ac.in/courses/108105062
- https://nptel.ac.in/courses/112104288

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Explain fundamentals of Robots. | L2 |
| CO2 | Apply kinematics and differential motions and velocities. | L3 |
| CO3 | Demonstrate control of manipulators. | L2 |
| CO4 | Understand robot vision. | L2 |
| CO5 | Develop robot cell design and programming. | L3 |

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| **23AMEM23** | **INDUSTRIAL AUTOMATION (Minor degree in Robotics and Automation)** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **3** |

**Course Objectives:**

- Impart the basic knowledge of automation and process control systems.
- Familiarize the automated flow lines and assembly line balancing.
- Demonstrate the primary material handling systems.
- Focus process industries, discrete manufacturing industries.
- Explain various control system components, programmable logic controllers and personal computers.

**UNIT – I: Introduction to Automation**

Need, Types, Basic elements of an automated system, Manufacturing Industries, Types of production, Functions in manufacturing, Organization and information processing in manufacturing, Automation strategies and levels of automation. Hardware components for automation and process control, mechanical feeders, hoppers, orienters, high-speed automatic insertion devices.

**UNIT – II: Automated Flow Lines and Assembly Line Balancing**

Automated Flow Lines: Part transfer methods and mechanisms, types of flow lines, flow line with/without buffer storage, Quantitative analysis of flow lines.

Assembly Line Balancing: Assembly process and systems assembly line, line balancing methods, ways of improving line balance, flexible assembly lines.

**UNIT – III: Material Handling and Identification Methods**

Material Handling Systems and Design: Introduction to Material Handling, Material Transport equipment, analysis of material transport systems, storage systems – storage system performance and location strategies, Conventional storage methods and equipment, Automated storage systems, Engineering analysis of storage systems.

Automatic Identification Methods: Overview of Identification Methods, Barcode technology, Radio frequency identification, other AIDC technologies.

**UNIT – IV: Industrial Control Systems**

Industrial Control Systems: Process industries Vs Discrete manufacturing industries, levels of automation in the two industries, variables and parameters in the two industries. Continuous Vs Discrete control – continuous control system, discrete control system.

Computer Process Control and Its Forms: Control requirements, capabilities of computer control and forms of computer process control.

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**UNIT – V: Control System Components, PLC and PC**

Control System Components: Sensors, Actuators, analog to digital convertors, digital to analog convertors, input/out devices for discrete data.

Programmable Logic Controllers and Personal Computers: Discrete process control, Programmable logic controllers, Ladder logic diagrams, personal computers using soft logic.

**Text Books:**

1. M.P. Groover, Automation, Production systems and Computer Integrated Manufacturing, 3/e, PHI Learning, 2013.
2. Geoffrey Boothroyd, Assembly Automation and Product design, Taylor and Francis Publishers, 2005.
3. Mikell P. Groover and Mitchell Weiss, Roger N. Nagel, Nicholas, G.Odrey, Industrial Robotics, Mc Graw Hill, 1986.

**Reference Books:**

1. Krishna Kant, Computer based industrial control, Prentice Hall of India, 2000.
2. Tiess Chiu chang and A.W.Richard, An introduction to automated process planning systems, Tata McGraw Hill, 2000.

**Online Learning Resources:**

- https://nptel.ac.in/courses/108105088
- https://nptel.ac.in/courses/108105063
- https://nptel.ac.in/courses/108105062
- https://nptel.ac.in/courses/112104288

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Apply the knowledge of an automation and process control strategies. | L3 |
| CO2 | Illustrate the automated flow lines and assembly line balancing. | L2 |
| CO3 | Utilize the basic material handling systems. | L3 |
| CO4 | Classify the process industries, discrete manufacturing industries and distinguish Continuous, Discrete control systems. | L2 |
| CO5 | Use various control system components and outline the programmable logic controllers and personal computers. | L3 |

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| **23AMEM24** | **HYDRAULICS AND PNEUMATICS CIRCUITS FOR ROBOTICS (Minor degree in Robotics and Automation)** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **3** |

**Course Objectives:**

- Familiarize on Fluid Power Engineering and Power Transmission System.
- Introduce the students, the basic concepts of hydraulic and pneumatic systems.
- Expose the students with various hydraulic and pneumatic actuators.
- Familiarize on fluid power systems and its applications to real time.
- Know the problem, which occur in fluid power systems and take necessary troubleshooting/ maintenance activities.
- Get practiced in designing hydraulic and pneumatic systems.
- Understand the design procedure available for Hydraulic and Pneumatic circuits.

**UNIT - I Introduction:**

Introduction: Introduction to fluid power - Types, advantages and application of fluid power systems. Properties of hydraulic fluids – General types of fluids – Fluid power symbols as per ISO/ANSI. Basic Components of Oil Hydraulic and Pneumatic Systems. Comparison of Mechanical, Electrical, Hydraulic & Pneumatic systems for force and motion analysis in automation.

**UNIT - II Oil Hydraulic Pumps, Actuators:**

Oil Hydraulic Pumps, Actuators: Types of hydraulic pumps - construction and working principle - design considerations, selection, specifications and characteristics of pumps. Types of actuators-construction and working principle - design considerations, selection, specifications and characteristics of actuators.

Control And Regulation Elements: Direction control valves, Pressure control valves, Flow control valves, Non-return valves, Reservoirs, Accumulators, Heating & cooling devices, Hoses. Selection of valves for hydraulic circuits.

**UNIT - III Design of Hydraulic Circuits:**

Design of Hydraulic Circuits: Speed control circuits - Regenerative circuits- Accumulators and Intensifiers: Types of accumulators – Accumulators circuits, sizing of accumulators, intensifier – Applications of Intensifier–Intensifier circuit. - Reservoir design - Selection of components. Hydraulic circuits - Reciprocating - Quick return - Sequencing synchronizing - Safety circuits - Industrial circuits - Press - Milling Machine - Planner - Fork Lift.

**UNIT - IV Pneumatic Systems:**

Pneumatic Systems: Pneumatic fundamentals - Properties of air – Compressors – Filter, Regulator, and Lubricator unit – Air control valves, Quick exhaust valves, and pneumatic actuators. Control Elements -

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Logic Circuits -Position - Pressure Sensing - Switching – Electro Pneumatic - Electro Hydraulic Circuits - Robotic Circuits.

**UNIT - V Design of Pneumatic Circuits:**

Design of Pneumatic Circuits: Classic-Cascade-Step counter - Combination -Methods - PLC-Microprocessors -Uses - Selection criteria for Pneumatic components - Installation and Maintenance of Hydraulic and Pneumatic power packs - Fault finding - Principles of Low Cost Automation - Case studies.

**Textbooks:**

1. Anthony Esposito, "Fluid Power with Applications", Pearson Education 2000.
2. Majumdar S.R, "Oil Hydraulics", Tata McGraw Hill, 2000.
3. Majumdar S.R, "Pneumatic Systems – Principles and Maintenance", Tata McGraw Hill, 2001.
4. Dudelyt, A. Pease and John T. Pippenger, "Basic Fluid Power", Prentice Hall, 1987.

**Reference Books:**

1. Andrew Parr, Hydraulic & Pneumatics, 2/e, Jaico Publishing House Elsevier, 1999.
2. Harry L. Stevart D.B, "Practical Guide to Fluid Power", Taraoeala Sons and Port Ltd. Broadey, 1976.

**Online Learning Resources:**

- Chrome-extension://efaidnbmnnibpcaglefindmkaj/viewer.htms?pdfhrl https%3A%2%2Fwww.iare.ac.in%2Fsites%2Fdefault%2Ffiles%2FDHPS%2520LECTURER%2520NOTES%2520FINAL.pdf&chunk=true.
- chromeextension://efaidnbmnnnibpcajpcglclefindmkaj/viewer.html?pdfurl=https%3A%2F%2Fwww.iare.ac.in%2Fsites%2Fdefault%2Ffiles%2FDHPS%2520PPT%2520%2520FINAL.pdf&chunk=true.
- https://nptel.ac.in/courses/112/105/112105047/

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Compare the differences between hydraulic and pneumatic systems. | L2 |
| CO2 | Identify the practical applications in automation. | L3 |
| CO3 | Build the circuits for a given applications. | L6 |
| CO4 | Develop hydraulic and pneumatic power packs. | L6 |
| CO5 | Discuss the importance of PLC and microprocessor in hydraulic and pneumatic systems. | L6 |

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|---|---|---|---|---|---|
| **23AMEM25** | **PROGRAMMING OF ROBOT (Minor degree in Robotics and Automation)** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **3** |

**Course Objectives:**

- Learn the fundamental concepts of industrial robotic technology.
- Apply the basic mathematics to calculate kinematic and dynamic forces in robot manipulator.
- Understand the robot controlling and programming methods.
- Describe concept of robot vision system.

**UNIT – I:** Fundamentals of Robots
Introduction, definition, classification and history of robotics, robot characteristics and precision of motion, advantages, disadvantages and applications of robots.

**UNIT – II:** Robot Actuators and Feedback Components
Actuators, Pneumatic, Hydraulic actuators, Electric & Stepper motors, comparison. Position sensors – potentiometers, resolvers, encoders - velocity sensors, Tactile sensors, Proximity sensors.

**UNIT – III:** Robot Programming
Methods of programming - requirements and features of programming languages, software packages, problems with programming languages. VAL, RAIL, AML, C, C++.

**UNIT – IV:** Control of Manipulators
Open and close – loop control, the manipulator control problem, linear control schemes, characteristics of second-order linear systems, linear second-order SISO model of a manipulator joint, joint actuators, partitioned PD control scheme, PID control Scheme, computer Torque control, force control of robotic manipulators, description of force-control tasks, force control strategies, hybrid position/force control, impedance force/torque control.

**UNIT – V:** Robot Vision
Introduction, architecture of robotic vision system, image processing, image acquisition camera, image enhancement, image segmentation, imaging transformation, Camera transformation and calibrations, industrial applications of robot vision.

**Text Books:**

1. Mikell P. Groover and Mitchell Weiss, Roger N. Nagel, Nicholas G.Odrey , Industrial Robotics — McGraw Hill, 1986.
2. R K Mittal and I J Nagrath, Robotics and control, Illustrated Edition, Tata McGraw Hill India 2003.

**Reference Books:**

1. Saeed B. Niku, Introduction to Robotics – Analysis, System, Applications, 2/e, John Wiley & Sons, 2010.

2. H. Asada and J.J.E. Slotine, Robot Analysis and Control, 1/e, Wiley- Inter science, 1986.
3. Robert J. Schillin, Fundamentals of Robotics: Analysis and control, Prentice-Hall Of India Pvt. Limited, 1996.
4. Mohsen shahinpoor, A robot Engineering text book, Harper & Row Publishers, 1987.
5. John.J.Craig Addison, Introduction to Robotics: Mechanics and Control, Wesley, 1999.
6. K.S. FU, R.C. Gonzalez and C.S.G Lee, Robotics: Control, sensing, vision, and intelligence. Mc Graw Hill, 1987.
7. Richard D. Klafter, Thomas Robotic Engineering an integrated approach, PHI publications 1988.

**Online Learning Resources:**

- https://nptel.ac.in/courses/112105249
- https://onlinecourses.nptel.ac.in/noc20_de11/preview
- https://nptel.ac.in/courses/112104308
- https://nptel.ac.in/courses/112104288
- https://nptel.ac.in/courses/112101099
- https://www.iare.ac.in/sites/default/files/lecture_notes/ROBOTICS_LECURE_NOTES.pdf

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Explain fundamentals of Robots. | L2 |
| CO2 | Apply kinematics and differential motions and velocities. | L4 |
| CO3 | Demonstrate control of manipulators. | L3 |
| CO4 | Understand robot vision. | L2 |
| CO5 | Develop robot cell design and programming. | L6 |

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|---|---|---|---|---|---|
| **23AMEM26** | **ROBOT OPERATING SYSTEM (Minor degree in Robotics and Automation)** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **3** |

**Course Objectives:**

- To introduce the students to the Robot Operating System (ROS) and its applications in robotic systems.
- To understand the communication architecture, tools, and utilities in ROS.
- To develop proficiency in ROS programming, robot modeling, and simulation environments.
- To build and simulate both mobile robots and manipulators in a virtual environment using URDF and Gazebo.
- To prepare students for practical application of ROS in real-time robotics and automation systems.

**UNIT-I**

**Introduction to ROS Framework and Prerequisites:**

Installation, Setting up the system and validation - Importance of ROS - Why ROS - Understanding communication in ROS (Final system level and Graph level)

**UNIT-II**

**ROS Ecosystem**

Getting started with ROS Programming, communication - ROS nodes, topics, messages - ROS Services

**UNIT-III**

**ROS Tools and Utilities (Mobile robot)**

URDF - Build robot using URDF and Visualize in RViz - Basic motions in ROS ROS Tools and Utilities (Manipulator) - Modelling and visualizing robots (Practical) - Solidworks to URDF

**UNIT-IV**

**Robot Modelling**

Students will model their own mobile robot, Modelling the environment, Students will make their own custom environment and make it ready for the robot simulation

**UNIT-V**

**Robot Tele-Operation**

ROS Gazebo full simulation

**Text Books:**

1. Morgan Quigley, " Programming robots with ROS: A practical introduction to the robot operating systems" O'Reilly media, 2015.
2. Carol Fairchild, Dr.Thoma L. Harman, "ROS Robotics by example", Packt, 2016.

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3. Anis Koubaa, "Robot Operating Systems" Springer link, 2016.
4. Anil mahtani, " Effective Robotics programming with ROS", Paket publishing, 2016.

**Online Learning Resources:**

- https://wiki.ros.org/ROS/Tutorials
- https://ivlabs.github.io/resources/robot-operating-system/
- https://www.youtube.com/watch?v=ENFiIGjSAt8
- https://www.autonomousrobotslab.com/learn-ros.html
- https://rsl.ethz.ch/education-students/lectures/ros.html

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Learn fundamentals, including key ROS Concepts, Tools, and Patterns. | L1 |
| CO2 | Programming robots that perform an increasingly complex set of behaviors, using the powerful packages in ROS. | L5 |
| CO3 | Students will model their own mobile robot, | L4 |
| CO4 | Identify the ROS Tools and Utilities (Mobile robots) | L1 |
| CO5 | Simulation through ROS Gazebo full simulation software | L5 |

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|---|---|---|---|---|---|
| 23AMEM27 | HYDRAULICS AND PNEUMATICS CIRCUITS LABORATORY (Minor degree in Robotics and Automation) | L | T | P | C |
| | | 0 | 0 | 3 | 1.5 |

**Course Objectives:**

- To provide hands-on experience in designing and simulating hydraulic and pneumatic circuits using Automation Studio software.
- To understand the functioning of series and parallel connections, meter-in and meter-out control, and hydraulic presses.
- To analyze and implement sequencing and synchronizing of actuators in both hydraulic and pneumatic systems.
- To practice circuit design using advanced methods like cascade and step counter techniques for automation.

**1. AUTOMATION STUDIO software.**

**I. Hydraulic Circuits**

a. Introduction to Automation studio & its control
b. Draw & Simulate the Hydraulic circuit for series & parallel cylinders connection
c. Draw & Simulate Meter-in, Meter-out and hydraulic press and clamping.
d. Sequencing circuits in hydraulics.
e. Synchronizing circuits in hydraulics.

**II. Pneumatic circuits**

a. Sequencing circuits in Pneumatics.
b. Synchronizing circuits in Pneumatics.
c. Design and Simulation of simple pneumatic circuit by using Cascade Method.
d. Design and Simulation of simple pneumatic circuit by using step counter method

**Textbook:**

1. Majumdar S.R., Pneumatic Systems: Principles and Maintenance, Tata McGraw-Hill Education, 2002.
2. Majumdar S.R., Oil Hydraulic Systems: Principles and Maintenance, Tata McGraw-Hill Education, 2002.
3. John Pippenger, Industrial Hydraulics, McGraw-Hill Education, 1987.
4. Andrew Parr, Hydraulics and Pneumatics: A Technician's and Engineer's Guide, 3rd Edition, Butterworth-Heinemann, 2011.

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**Online Learning Resources:**

- https://www.festo-didactic.com
- https://www.youtube.com/results?search_query=automation+studio+hydraulics+pneumatics
- https://nptel.ac.in/courses/112106281
- https://www.automationstudio.com/en/

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Understand the basics and functionalities of Automation Studio software for fluid power systems. | L1 |
| CO2 | Design and simulate hydraulic circuits including series/parallel connections, meter in/meter-out, and clamping systems. | L3 |
| CO3 | Analyze and implement sequencing and synchronizing operations in hydraulic circuits. | L4 |
| CO4 | Design and simulate pneumatic circuits using sequencing and synchronizing techniques. | L3 |
| CO5 | Design pneumatic circuits using advanced control techniques like cascade and step counter methods. | L5 |

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|---|---|---|---|---|---|
| **23AMEM28** | **ROBOT PROGRAMMING LAB (Minor degree in Robotics and Automation)** | **L** | **T** | **P** | **C** |
| | | **0** | **0** | **3** | **1.5** |

**Course Objectives:**

- To provide hands-on experience in robot programming using Flex Pendant and VAL language.
- To develop skills in motion control, interpolation, and manipulation using industrial robot systems.
- To introduce ROS (Robot Operating System) for simulation and control of robots.
- To enable students to build autonomous robots with perception, planning, and localization capabilities.
- To apply robot programming to real-world applications such as palletizing, pick-and-place, and welding.

## LIST OF EXERCISES

Any **twelve** exercises from the following to be performed

1. Robot Programming using Flex Pendant – Lead through programming including coordinate systems of robot.
2. Wrist mechanism – Interpolation-Interlock commands.
3. VAL Language commands motion control, hand control, program control, pick and place applications.
4. Palletizing applications using VAL.
5. Object Detection and Sorting.
6. Robot welding application using VAL program.
7. Endowing mobile autonomous robots with planning, perception, and decision-making capabilities.
8. Trajectory optimization.
9. Robot motion planning and perception.
10. Robot, localization, and simultaneous localization and mapping.
11. Robot Operating System (ROS) for demonstrations and hand on activities.

**Text Books:-**

1. Hughes Cameron, "Robot Programming" Pearson Publishers, 2016.
2. J.Srinivas, "Robotics: Control and Programming", Narosa publications, 2009.
3. Morgan Quigley, " Programming robots with ROS: A practical introduction to the robot operating systems" O'Reilly media, 2015.
4. Carol Fairchild, Dr.Thoma L. Harman, "ROS Robotics by example", Packt, 2016.

**Online Learning Resources:**

- https://nptel.ac.in/courses/112105249
- https://www.youtube.com/results?search_query=ros+tutorials+robot+programming
- https://www.edx.org/course/robotics
- https://github.com/ros

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| **CO1** | Learn fundamentals of robot programming including key concepts in ROS, Flex Pendant, and VAL. | L1 |
| **CO2** | Implement basic and advanced robot motion control using programming tools. | L3 |
| **CO3** | Develop robot applications such as pick-and-place, palletizing, and welding. | L4 |
| **CO4** | Build autonomous robots with localization, planning, and decision-making. | L5 |
| **CO5** | Program robots to perform complex behaviors using advanced ROS packages. | L6 |

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# Courses offered for Honors degree

# B.Tech – Mechanical Engineering

| S.No. | Course Code | Course Title | Offered in Semester | Contact Hours per week | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | | L | T | P | |
| 1 | 23AMEH01 | Advanced Automotive Electronics | V | 3 | 0 | 0 | 3 |
| 2 | 23AMEH02 | Application of Computational Fluid Dynamics | VII | 3 | 0 | 0 | 3 |
| 3 | 23AMEH03 | Mechanics and manufacturing of Composite materials | VI | 3 | 0 | 0 | 3 |
| 4 | 23AMEH04 | Applications of Optimization Techniques | V | 3 | 0 | 0 | 3 |
| 5 | 23AMEH05 | Advanced Mechanical Vibrations | VI | 3 | 0 | 0 | 3 |
| 6 | 23AMEH06 | Honor's degree Project work | VII | 0 | 0 | 6 | 3 |
| Total | | | | 15 | 0 | 6 | 18 |

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|---|---|---|---|---|---|
| 23AMEH01 | ADVANCED AUTOMOTIVE ELECTRONICS<br>Honors Degree course - 1 | L | T | P | C |
| | | 3 | 0 | 0 | 3 |

**Course Objectives:**

- Explain the use of electronics in the automobile.
- Explain the importance of various types of sensors and actuators in automotive electronics.
- Demonstrate the various control elements in Engine Management system.
- Familiarize with Vehicle management systems
- Identify various electronic and the instrumentation systems used in automobile.

**UNIT – I:** Introduction to microcomputer:
Introduction to microcomputer: Microcomputer: Buses, memory, timing, CPU registers; Microprocessor architecture: Initialization, operation codes, program counter, branch and jump instructions, subroutine. Analog to digital converters and Digital to analog converters, sampling, polling and interrupts, digital filters, lookup table.

**UNIT – II:** Sensors and actuators:
Sensors and actuators: Speed sensors, Pressure sensors: Manifold Absolute Pressure sensor, knock sensor, Temperature sensors: Coolant and Exhaust gas temperature, Exhaust Oxygen level sensor, Position sensors: Throttle position sensor, accelerator pedal position sensor and crankshaft position sensor, Air mass flow sensor. Solenoids, stepper motors and relays.

**UNIT – III:** Electronic engine management system:
Electronic engine management system: Electronic engine control: Input, output and control strategies, electronic fuel control system, fuel control modes: open loop and closed loop control at various modes, EGR control, Electronic ignition systems – Spark advance correction schemes, fuel injection timing control

**UNIT – IV:** Electronic vehicle management system:
Electronic vehicle management system: Cruise control system, Antilock braking system, electronic suspension system, electronic steering control, traction control system, Transmission control, Safety: Airbags, collision avoiding system, low tire pressure warning system.

**UNIT – V:** Automotive instrumentation system :
Automotive instrumentation system: Input and output signal conversion, multiplexing, fuel quantity measurement, coolant temperature and oil pressure measurement, display devices- LED, LCD, VFD and CRT, Onboard diagnostics(OBD), OBD-II, off board diagnostics.

**Text Books:**


1. Understanding Automotive Electronics, William B Ribbens, Newne Butterworth-Heinermann,6/e, 2003.
2. Crouse W H, Automobile Elctrical Equipment, McGraw Hill Book Co.Inc, Newyork 2005.

**Reference Books:**


1. Bechhold "Understanding Automotive Electronics", SAE, 1998.
2. Robert Bosch "Automotive Hand Book", SAE (5th Edition), 2000.
3. Tom Denton,"Automobile Electrical and Electronic Systems" 3rd edition- Edward Arnold, London - 2004.
4. Eric Chowanietz - 'Automotive Electronics' - SAE International USA – 1995.


**Online Learning Resources:**

- https://nptel.ac.in/courses/107106088
- https://www.youtube.com/watch?v=BOP8qLQzhDc
- https://nptel.ac.in/courses/108104140
- https://intranet.cb.amrita.edu/sites/default/files/164-AutomotiveElectronics.pdf
- http://digimat.in/nptel/courscs/vidco/108108147/L01.html
- https://jssstuniv.in/wp-content/uploads/2020/09/M.Tech-Automotive-Electronics-_Final.pdf

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Obtain an overview of automotive components, like sensors, actuators, communication protocols and safety systems employed in today's automotive industry. | L1 |
| CO2 | Interface automotive sensors and actuators with microcontrollers. | L2 |
| CO3 | Know, the various display devices that are used in automobiles. | L2 |
| CO4 | Identify the elements in the engine management and vehicle management system. | L2 |
| CO5 | Obtain an overview of automotive components, like sensors, actuators, communication protocols and safety systems employed in today's automotive industry | L1 |

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|---|---|---|---|---|---|
| | | L | T | P | C |
| 23AMEH02 | APPLICATIONS OF COMPUTATIONAL FLUID DYNAMICS<br>Honors Degree course - 2 | 3 | 0 | 0 | 3 |

**Course Objectives:**

- Teach the basics of the major theories, approaches and methodologies used in CFD.
- Familiar with the differential equations for flow phenomena and numerical methods for their solutions.
- Introduce explicit and implicit schemes in hyperbolic equations.
- Expose the students to solve the problems through finite volume method.
- Understand the concepts of linear fluid flow problems, steady state problems and transient problems.

**UNIT – I:** Introduction and Solution methods

Introduction: Finite difference method, finite volume method, finite element method, governing equations and boundary conditions, Derivation of finite difference equations.

Solution methods: Solution methods of elliptical equations — finite difference formulations, interactive solution methods, direct method with Gaussian elimination. Parabolic equations-explicit schemes and Von Neumann stability analysis, implicit schemes, alternating direction implicit schemes, approximate factorization, fractional step methods, direct method with tridiagonal matrix algorithm.

**UNIT - II** Hyperbolic equations:

Hyperbolic equations: explicit schemes and Von Neumann stability analysis, implicit schemes, multi step methods, nonlinear problems, second order one-dimensional wave equations. Burgers equations: Explicit and implicit schemes, Runge-Kutta method.

**UNIT - III** Formulations of Incompressible Viscous Flows

Formulations of Incompressible Viscous Flows: Formulations of incompressible viscous flows by finite difference methods, pressure correction methods, vortex methods.

Treatment of compressible flows: potential equation, Euler equations, Navier-stokes system of equations, flow field-dependent variation methods, boundary conditions, example problems.

**UNIT - IV** Finite Volume Method:

Finite Volume Method: Finite volume method via finite difference method, formulations for two and three-dimensional problems.

**UNIT - V** Standard Variational Methods:

Standard Variational Methods: Linear fluid flow problems, steady state problems, Transient problems.

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**Text books:**

1. Computational fluid dynamics/ T. J. C'hung/ Cambridge University press, 2002.
2. Computational Fluid Dynamics: Basics with applications/John D. Anderson/ Mc Graw Hill.

**Reference Books:**

1. Text book of fluid dynamics/ Frank Choriton/ CBS Publishers & distributors, 1985.
2. Numerical heat transfer and fluid flow / Suhas V. Patankar/ Hema shava Publishers corporation & Mc Graw Hill.
3. Computational Fluid Flow and Heat Transfer/ Muralidaran/ Narosa Publications.
4. Fundamentals of Computational Fluid Dynamics/Tapan K. Sengupta / Universities Press.
5. Introduction to Theoretical and Computational Fluid Dynamics/C. Pozrikidis /Oxford

**Online Learning Resources:**

- https://onlinecourses.nptel.ac.in/noc24_ae23/preview
- https://onlinecourses.nptel.ac.in/noc21_me126/preview
- https://onlinecourses.nptel.ac.in/noc25_ch18/preview
- https://www.classcentral.com/course/swayam-cfd-applications-in-chemical-processes-452069
- https://www.classcentral.com/subject/computational-fluid-dynamics

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Understand the fundamental principles of CFD and classify governing equations based on physical behavior. | L2 |
| CO2 | Apply finite difference and finite volume techniques to discretize and solve basic fluid flow equations. | L3 |
| CO3 | Analyze the stability and accuracy of numerical schemes such as explicit and implicit methods. | L4 |
| CO4 | Develop algorithms to solve hyperbolic, parabolic, and elliptic partial differential equations. | L5 |
| CO5 | Simulate steady and transient fluid flow problems using computational approaches and interpret the results. | L6 |

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|---|---|---|---|---|---|
| 23AMEH03 | MECHANICS AND MANUFACTURING OF COMPOSITE MATERIALS<br>Honors Degree course - 3 | L | T | P | C |
| | | 3 | 0 | 0 | 3 |

**Course Objectives:**

- Course Objectives: The objectives of the course are to make the students learn about
- Understand the properties of composite materials.
- Familiarize the manufacturing methods for composites.
- Teach the practical requirements associated with joining and manufacturing

**UNIT – I:** Introduction to Composite Materials:
Definition, classification and characteristics of composite Materials – fibrous composites, laminated composites, particulate composites. Applications: Automobile, Aircrafts. missiles. Space hardware, Electrical and electronics, Marine, recreational and sports equipment, future potential of composites.

Fiber Reinforced Plastic Processing: Lay-up and curing, fabricating process, open and closed mould process, hand lay-up techniques; structural laminate bag molding, production procedures for bag molding; filament winding, pultrusion, pulforming, thermo-forming, injection molding, blow molding.

**UNIT – II:**
Micro Mechanical Analysis of a Lamina: Introduction, Evaluation of the four elastic moduli by Rule of mixture, Numerical problems.

Macro Mechanics of a Lamina: Hooke's law for different types of materials, Number of elastic constants, Two - dimensional relationship of compliance and stiffness matrix. Hooke's law for two-dimensional angle lamina, engineering constants - Numerical problems. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems.

**UNIT – III:**
Biaxial Strength Theories: Maximum stress theory, Maximum strain theory, Tsai-Hill theory, Tsai, Wu tensor theory, Numerical problems.

Macro Mechanical Analysis of Laminate: Introduction, code, Kirchoff hypothesis, CL T, A, B, and D matrices (Detailed derivation) , Special cases of laminates, Numerical problems.

**UNIT – IV:**
Metal Matrix Composites: Metal Matrix Composites: Reinforcement materials, types, characteristics and selection base metals selection. Need for production MMC's and its application.

Fabrication Process For MMC's: Powder metallurgy technique, liquid metallurgy technique and secondary processing, special fabrication techniques.

Study Properties Of MMC's: Physical Mechanical, Wear, machinability and Other Properties. Effect of size, shape and distribution of particulate on properties.

**UNIT – V:**

Failure Theories: Micromechanics of Failure of Unidirectional Lamina, Anisotropic Strength and Failure Theories, Importance of Shear Strength, Choice of Failure Criteria, Examples.

**Text Books:**


1. K.K. Chawla, Composite Materials, Springer-Verlag, New York. 1998.
2. B.T. Astrom, Manufacturing of Polymer Composites, Chapman & Hall, 1997.
3. Stuart M Lee, J. Ian Gray, Miltz, Reference Book for Composites Technology, CRC press, 1989.


**Reference Books:**


1. Frank L Matthews and R D Rawlings, Composite Materials: Engineering and Science, Taylor and Francis, 2006.
2. Hull and T.W. Clyne, Introduction to Composite Materials, Cambridge University Press, 1996.
3. M.R. Piggott, Load Bearing Fibre Composites, Pergamon press, Oxford, 1998.
4. Ashby and D.R.H. Jones, Engineering Materials, Pergamon press, 1999.
5. R.W. Davidge and A. Kelly, Mechanical behavior of ceramics, Cambridge university press, 1999.
6. Andrew C. Marshall, Composite Basics, Marshall Consulting. Mode of Evaluation Quiz/Assignment/ Seminar/Written Examination, 1998.


**Online Learning Resources:**

- https://nptel.ac.in/courses/112104221
- https://nptel.ac.in/courses/112104229
- https://nptel.ac.in/courses/112104161
- https://onlinecourses.nptel.ac.in/noc22_me40/preview.

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Design and manufacture composite materials for various applications. | L5 |
| CO2 | Explain Micro Mechanical Analysis of a Lamina | L2 |
| CO3 | Synthesize structures for environmental effects. | L5 |
| CO4 | Analyse economic aspects of using composites. | L4 |
| CO5 | Conduct mechanical testing of composite structures and analyse failure modes. | L4 |

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|---|---|---|---|---|---|
| | | L | T | P | C |
| 23AMEH04 | APPLICATIONS OF OPTIMIZATION TECHNIQUES<br>Honors Degree course - 4 | 3 | 0 | 0 | 3 |

**Course Objectives:**

- Explain principles of optimization and its need.
- Familiarization with theory of optimization methods and algorithms developed for solving various types of optimization problems.
- Understand the mathematical foundations for Genetic Algorithm, Operators.
- Know fundamental theory and concepts of neural networks, neuro – modelling, several neural network paradigms and its applications.
- Identify the application of optimization to design of machine elements.

**UNIT – I:** Introduction:
Classical Optimization Techniques: Single variable optimization with and without Constraints, Multi – Variable Optimization without constraints, Multi – Variable Optimization with Constraints – Method of Lagrange Multipliers, Kuhn-Tucker Conditions.

Numerical Methods for Optimization: Interval Halving Method, Fibonacci Method, Quadratic Interpolation Method, Newton Method, Quasi Newton Method, Secant Method.

**UNIT – II:** Genetic Algorithm (GA):
Differences and Similarities between Conventional and Evolutionary Algorithms, Working Principle, Reproduction, Crossover, Mutation, Termination Criteria, Different Reproduction and Crossover Operators, GA for Constrained Optimization, Draw Backs of GA.

**UNIT – III:** Genetic Programming (GP):
Principles of Genetic Programming, Terminal Sets, Functional Sets, Differences between GA & GP, Random Population Generation, Solving Differential Equations using GP.

**UNIT – IV:** Neural networks :
Introduction to Neural networks: Knowledge base information processing, General View of Knowledge Based Algorithm, Neural Information Processing, Hybrid Intelligence and Artificial Neurons.

Characteristics of Artificial Neural Networks: Single Neural Networks, Multi – Layer Neural Networks, Training of ANN – Objective, Supervise Training, Unsupervised Training, Overview of training.

**UNIT – V:** Applications of Optimization in Design and Manufacturing Systems:
Some typical applications like Optimization of Path Synthesis of a Four – bar Mechanism, Minimization of Weight of a Cantilever Beam, Optimization of Springs and Gears, General Optimization model of a Machining Process, Optimization of Arc Welding Parameters and General Procedure in Optimizing Machining Operations Sequence.

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**Text Books:**

1. Singiresu S. Rao, Engineering Optimization, 3/e, New Age Publishers, 2010
2. Bart Kosko, Neural Networks and Fuzzy System, 2/e, Prentice Hall of India, 2001
3. Goldberg D.E., Genetic algorithms in Search, Optimization, and Machine learning, 4/e, Pearson, 2009.
4. Kalyanmoy Deb, Optimization for Engineering Design: Algorithms and Examples, 2/e, PHI Learning Pvt. Ltd., 2012.

**Reference Books:**

1. Kalyanmoy Deb, Multi Objective Optimization using Evolutionary Algorithms, 1/e, John Wiley and Sons, 2001.
2. Jasbir S. Arora, Introduction to Optimum Design, 4/e, Academic Press, 2016.
3. Ravindran A., Engineering Optimization Methods and Applications, 2/e, John Wiley and Sons, 2006
4. Fox R.L., Optimization Methods for Engineering Design, 1/e, Addison Wesley Publication Co., 1971.

**Online Learning Resources:**

- https://nptel.ac.in/courses/107106088
- https://www.youtube.com/watch?v=BOP8qLQzhDc
- https://nptel.ac.in/courses/108104140
- https://intranet.cb.amrita.edu/sites/default/files/164-AutomotiveElectronics.pdf
- http://digimat.in/nptel/courses/video/108108147/L01.html
- https://jssstuniv.in/wp-content/uploads/2020/09/M.Tech-Automotive-Electronics-_Final.pdf

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Know the principles of optimization and its need. | L2 |
| CO2 | Identify optimization methods and algorithms developed for solving various types of optimization problems. | L2 |
| CO3 | Understand and appreciate the basic concepts of Genetic Algorithms and results of applying various genetic operators. | L3 |
| CO4 | Solve the concepts of Neural Networks for training and validation of neural network models. | L6 |
| CO5 | Know the principles of optimization and its need. | L2 |

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| | | L | T | P | C |
| 23AMEH05 | ADVANCED MECHANICAL VIBRATIONS<br>Honors Degree course - 5 | 3 | 0 | 0 | 3 |

**Course Objectives:**

- Introduce the fundamental principles of mechanical vibrations including free and forced vibrations, damping, and transient response.
- Familiarize students with vibration isolation techniques, vibration absorbers, and stability criteria.
- Provide a deep understanding of nonlinear and random vibration phenomena and analytical methods.
- Explore the vibration behavior of rotating machinery including critical speeds, torsional vibrations, and flow-induced vibrations.
- Equip students with the knowledge of vibration-based diagnostic techniques and instrumentation, including signal analysis and AI-based fault detection.

**Unit – I:**

**Introduction:** Free and forced vibrations with and without damping, transient vibrations, Laplace transform formulation.

**Unit – II:**

**Isolation and Stability Criterion:** Vibration isolation and transmissibility, undamped vibration absorbers, self-exited vibrations, criterion of stability, effect of friction on stability.

**Unit – III:**

**Nonlinear Vibration:** Free vibration with nonlinear spring force or nonlinear damping, phase plane, energy curves, Lienard's graphical construction, methods of isoclines, random vibration, power spectral density, bandwidth in vibration, numerical methods for vibration analysis, vibration of continuous systems, Euler equation for beams, effect of rotary inertia and shear deformation.

**Unit – IV:**

**Vibration Analysis of Rotors:** Transverse vibrations single, two and three rotor systems, critical speeds of shafts, torsional vibrations of rotors: one, two and three disc rotor system, frequency of torsional vibration systems, coupling of torsional and bending vibrations due to pretwist and eccentricity, rotor faults, forward and backward rotor whirl model, variable elasticity effects in rotating systems, flow induced vibration in rotating systems, Newkirk effect, stresses in rotating disc and blade, disc of uniform strength, thermal stresses.

**Unit – V:**

**Diagnostic Techniques:** Introduction to diagnostic maintenance and instrumentation in machinery vibration, amplitude, frequency and phase characteristics, signature analysis-trend plot, time domain plot, frequency domain plot, FFT, spectrum plot, fault detection transducers, artificial intelligence techniques applied to vibration analysis.

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**Text Books:**


1. S. S. Rao. Mechanical Vibrations, 4th Edition, Pearson Education, 2007.
2. L. Meirovitch. Fundamentals of Vibrations, McGraw Hill, 1 st edition, 2001.
3. E. Krämer. Dynamics of Rotors and Foundations, Springer-Verlag, New York, 1993.
4. R. Subbiah and J. E. Littleton. Rotor and Structural Dynamics of Turbo machinery-A Practical, 1st edition, 2018.
5. P. Luciano Gatti. Advanced Mechanical Vibrations: Physics, Mathematics and Applications. CRC Press; 1st edition 2020.


**Online Learning Resources:**

- https://nptel.ac.in/courses/112106215
- https://nptel.ac.in/courses/112106318
- https://nptel.ac.in/courses/112106230
- https://www.ansys.com/academic/students
- https://www.youtube.com/playlist?list=PLUl4u3cNGP63EdVPNLG3ToM6LaEUuStEY

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Understand the fundamentals of free and forced vibrations with and without damping using analytical and Laplace methods. | L2 |
| CO2 | Apply concepts of vibration isolation, absorbers, and stability criteria to practical engineering systems. | L3 |
| CO3 | Analyze nonlinear and random vibration systems using graphical, numerical, and spectral methods. | L4 |
| CO4 | Evaluate the dynamic behavior of rotating shafts and rotor systems including critical speeds and coupled vibrations. | L5 |
| CO5 | Interpret vibration signatures using diagnostic tools and AI-based methods for fault detection and maintenance. | L5 |

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| | | L | T | P | C |
| 23AMEH06 | ADVANCED HEAT TRANSFER<br>Honors Degree course - 6 | 3 | 0 | 0 | 3 |

**Course Objectives:**

- Provide an in-depth understanding of heat conduction, including internal heat generation, transient and multidimensional conduction using analytical and graphical methods.
- Develop analytical skills for steady-state and transient heat transfer through extended surfaces and their optimization.
- Explore advanced concepts in forced and natural convection, including empirical relations for various configurations and fluids.
- Examine convection with phase change such as condensation and boiling, with a focus on physical mechanisms and design implications.
- Introduce advanced radiation heat transfer topics, including gas radiation, radiation in enclosures, and practical applications like human body heat transfer and furnace design.

**Unit I:**

Heat conduction with heat generation: Plane wall and cylinder with uniform heat generation, ·lications. Two-dimensional steady state conduction, Transient and multi-dimensional heat ·n: Exact solution, use of Heisler and Grober chart, integrated method.

·nsfer through extended surfaces: Steady state analysis and optimization, radial fins of ·lar and hyperbolic profiles longitudinal fin of rectangular profile radiating to free space.

**:**

·ive Heat Transfer: Forced convection: Introduction, heat transfer in high velocity flow, ·l relations for pipe and tube flow, flow across cylinders, spheres and tube banks, liquid-metal heat transfer. Natural Convection: Introduction, empirical relations for free convection, free convection from vertical planes, cylinders, horizontal cylinders, horizontal plates, inclined surfaces, spheres and enclosed space, non-newtonian fluids, combined free and forced convection.

**Unit IV:**

Convection with change of phase: Condensation: Laminar film on a vertical surface, Turbulent film on a vertical surface, Film condensation in other configurations, Drop condensation, effect of non-condensable gases in condensing equipments.

Boiling: Pool boiling regimes, Nucleate boiling and peak heat flux, Film boiling and minimum heat flux, Flow boiling.

**Unit V:**

Radiation heat transfer: Radiation effect on temperature measurements, radiation properties of a participating medium, emissivity and absorptivity of gases and gases mixtures, heat transfer from the human body, radiative exchange and overall heat transfer in furnaces.

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**Reference Books:**


1. D.P. Incropera, P.P. and Dewitt, Fundamentals of Heat and Mass Transfer, Wiley Eastern
2. Adrian Bejan, Convective Heat Transfer, Wiley India.
3. Cengel Y A, Heat Transfer – A Practical Approach, McGraw Hill
4. Kays, Crawford and Weigand, Convective Heat and Mass Transfer, McGraw Hill.
6. Siegel and Howell, Thermal Radiation, McGraw Hill.
7. Kraus A.D., Aziz, A., and Welty, J., Extended Surface Heat Transfer, McGraw Hill
8. Adrian Bejan, Allan D. Krams, Heat Transfer Handbook, John Wiley & Sons.
9. J. P. Holman, Heat Transfer, McGraw Hill.


**Online Learning Resources:**

- https://nptel.ac.in/courses/112105182
- https://nptel.ac.in/courses/112105173
- https://nptel.ac.in/courses/112105250
- https://ocw.mit.edu/courses/mechanical-engineering/2-51-intermediate-heat-and-mass-transfer-january-iap-2007/
- https://www.ansys.com/products/fluids/ansys-fluent

**Course Outcomes:**

| COs | Statements | Blooms Level |
|---|---|---|
| CO1 | Analyze one-dimensional and two-dimensional steady and unsteady heat conduction problems. | L5 |
| CO2 | Solve and optimize heat transfer problems involving extended surfaces (fins). | L6 |
| CO3 | Interpret and apply convective heat transfer correlations for various flow configurations. | L2 |
| CO4 | Examine boiling and condensation heat transfer mechanisms and predict heat flux. | L2 |
| CO5 | Apply principles of radiative heat transfer to practical systems such as furnaces. | L1 |

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