CURRICULUM

M.TECH.

IN

MANUFACTURING TECHNOLOGY WITH MACHINE LEARNING

(JULY 2023 ADMISSIONS ONWARDS)

APPROVED BY

BOARD OF STUDIES (BOS)

During meeting on May 16, 2023

TEACHING SCHEME

DEPARTMENT OF INDUSTRIAL & PRODUCTION ENGINEERING

Dr B R AMBEDKAR NATIONAL INSTITUTE OF TECHNOLOGY, JALANDHAR

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Programme Educational Objectives (PEOs):

1. **PEO 1:** Blend foundational Engineering principles with advanced manufacturing Engineering concepts.
2. **PEO 2:** Excel in manufacturing roles and overcome future challenges with ease.
3. **PEO 3:** Apply Machine Learning techniques to enhance manufacturing processes and develop innovative solutions in Manufacturing Engineering.

Programme Outcomes (POs):

Sr. No	Attributes	Programme Outcomes (POs)
1	Scholarship of Knowledge	Acquire in depth knowledge in Manufacturing technology with an ability to define, evaluate, analysis and synthesize existing and new knowledge.
2	Critical Thinking	Analyse problems critically; apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research.
3	Problem Solving	Conceptualize and solve Manufacturing engineering problems and evaluate optimal solutions considering economic and eco-friendly factors
4	Research Skill	Develop scientific/ technological knowledge in Manufacturing engineering through literature survey and design of experiments.
5	Usage of modern tools	Apply of IT tools such as CAD/CAE/CAM for modelling and simulation of complex Manufacturing processes.
6	Collaborative and multi-disciplinary work	Perform collaborate multidisciplinary scientific Manufacturing engineering research through self-management and team work.
7	Project Management and Finance	Demonstrate knowledge and understanding of Manufacturing engineering and management and apply the same to one's own work, as a member and leader in team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economical and financial factors.
8	Communication	Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.
9	Life-long Learning	Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.
10	Ethical Practices and Social Responsibility	Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.
11	Independent and Reflective Learning	Observe and examine critically the outcomes of one's actions and make corrective measures subsequently and learn from mistakes without depending on external feedback.

Course Structure and Scheme for M. Tech Programme (Full Time) in Manufacturing Technology with Machine Learning

Total Credits = 65

SEMESTER – I

Sr. No.	Course-Code	Course Title	Hrs/week			Credits
			L	T	P	
1	IP-551	Computer Aided Engineering	3	0	0	3
2	IP-552	Theory of Production Processes-I	3	0	0	3
3	IP-553	Additive Manufacturing	3	0	0	3
4	IP-554	Surface Engineering	3	0	0	3
5	IP-555	Machine Learning-I	3	0	0	3
6	IP-***	Program Elective-I	3	0	0	3
7	IP-595	Computer Aided Engineering and Machine Learning Lab	0	0	3	2
8	IP-596	Manufacturing Lab-I	0	0	3	2
Total			**18**	**0**	**6**	**22**

SEMESTER – II

Sr. No.	Course-Code	Course Title	Hrs/week			Credits
			L	T	P	
1	IP-556	Industrial Internet of Things	3	0	0	3
2	IP-557	Industrial Automation and Robotics	3	0	0	3
3	IP-558	Theory of Production Processes-II	3	0	0	3
4	IP-559	High Precision Manufacturing	3	0	0	3
5	IP-560	Machine Learning-II	3	0	0	3
6	IP-***	Program Elective-II	3	0	0	3
7	IP-597	Automation, IOT and ML Lab	0	0	3	2
8	IP-598	Manufacturing Lab-II	0	0	3	2
Total			**18**	**0**	**6**	**22**

SEMESTER – III

Sr. No.	Course-Code	Course Title	Hrs/week			Credits
			L	T	P	
1	IP-601	Seminar	0	0	6	3
2	IP-600	Dissertation (Phase-I)**	0	0	12	6
Total			**0**	**0**	**18**	**9**

SEMESTER - IV

Sr. No.	Course-Code	Course Title	Hrs/week			Credits
			L	T	P	
1	IP-600	Dissertation (Phase-II)**	0	0	24	12
Total			**0**	**0**	**24**	**12**

LIST OF ELECTIVES

Sr. No.	Course-Code	Course Title	Hrs/week			Credits
			L	T	P	
1	IP-561	Advanced Materials (including Composites & Plastics)	3	0	0	3
2	IP-562	Computer Integrated Manufacturing	3	0	0	3
3	IP-563	Design for Manufacturing and Assembly	3	0	0	3
4	IP-564	Fatigue in Manufacturing	3	0	0	3
5	IP-565	Finite Element Methods	3	0	0	3
6	IP-566	Inspection and Testing in Manufacturing	3	0	0	3
7	IP-567	Lasers in Manufacturing	3	0	0	3
8	IP-568	Machine Tool Design	3	0	0	3
9	IP-569	Machining Science	3	0	0	3
10	IP-570	Mathematical Methods in Engineering	3	0	0	3
11	IP-571	Mechanics of Composite Materials	3	0	0	3
12	IP-572	Non-Conventional Machining Techniques	3	0	0	3
13	IP-573	Smart Materials and MEMS	3	0	0	3
14	IP-574	Theory of plasticity	3	0	0	3
15	IP-575	Tribology	3	0	0	3
16	IP-576	Welding Metallurgy	3	0	0	3
17	IP-577	Big Data Analytics for Manufacturing	3	0	0	3
18	IP-578	Cyber security for Manufacturing	3	0	0	3
19	IP-579	Advanced Computational Techniques	3	0	0	3
20	IP-580	Design and Analysis of Experiments	3	0	0	3
21	IP-581	Sustainable Manufacturing	3	0	0	3
22	IP-582	Materials Engineering & Characterization	3	0	0	3
23	IEA-505	Modelling and Simulation	3	0	0	3
24	IEA-507	Work Systems Design	3	0	0	3
25	IEA-509	Advanced Operations Research	3	0	0	3
26	IEA-521	Project Management	3	0	0	3
27	IEA-523	Product Design & Development	3	0	0	3
28	IEA-526	Occupational Health and Safety Management	3	0	0	3

IP-551 COMPUTER AIDED ENGINEERING [3- 0 -0 -3]

COURSE OUTCOMES

CO1. Students will be able to use CAD software to create 2D and 3D models.
CO2. Students will be able to generate tool paths for CAM.
CO3. Students will be able to conduct FEA simulations to analyze and optimize designs.
CO4. Students will be able to evaluate the advantages and limitations of CAD, CAM, and FEA

DETAILED SYLLABUS

Introduction to CAD, CAM, and FEA: Definition and scope of CAD, CAM, and FEA, Brief history of CAD, CAM, and FEA, Advantages and limitations of CAD, CAM, and FEA, Overview of CAD, CAM, and FEA software
CAD Fundamentals: Sketching techniques and constraints, Basic 2D drawing commands and tools, Dimensioning and annotation, Basic 3D modeling techniques, Creating assemblies and exploded views

CAD Advanced Techniques: Advanced 3D modeling techniques, Surface modeling, Sheet metal design, Parametric modeling and design automation

CAM Fundamentals: Introduction to CAM and CNC machining, Generating tool paths for milling and turning operations, Post-processing and simulation of tool paths, CAM software demonstrations and practice

Introduction to FEA: Basic concepts and terminology of FEA, Types of FEA simulations (static, dynamic, thermal, etc.), FEA workflow and process, FEA software demonstrations and practice,

FEA Applications: Analyzing stress and deformation of mechanical parts, Evaluating fluid flow and heat transfer. Optimizing designs using FEA, Case studies and examples of FEA simulations Integration of CAD, CAM, and FEA: Importing and exporting CAD models to CAM and FEA software, Linking CAD, CAM, and FEA software for design optimization, Collaborative design using CAD, CAM, and FEA

TEXT BOOKS

1. Machining and CNC Technology by Michael Fitzpatrick and Steve Krar, 3rd Edition, 2020.
2. Donald Hearn, M Pauline Baker, Computer Graphics, Third Edition, Prentice-Hall, 1994
3. Faux, I D and Pratt, M J, Computational Geometry for Design and Manufacture, John Wiley and Sons, NY, 1979.
4. Groover M P, "Automation, Production System and Computer Aided Manufacture", Prentice Hall, 1984.
5. Ibrahim Zeid, "CAD/CAM Theory and Practice", McGraw-Hill, 1991.
6. Mortenson, M E, Geometric Modelling, John Wiley and Sons, NY, 1991.
7. Reddy,J N., ―Introduction to Finite Element Method‖, McGraw Hill, 1993
8. Finite Element Analysis: Theory, Application, and Implementation by M. Asghar Bhatti, 2nd Edition, 2019.

REFRENCE BOOKS

1. CAD/CAM: Principles and Applications by P.N. Rao, 3rd Edition, 2020.

2. Radhakrishnan P & Kothandaraman C P, "Computer Graphics and Design", Dhanpat Rai & Sons, 1990.
3. Stover R, "An analysis of CAD/CAM application with Introduction to CIM", Prentice Hall Inc., Englewood Cliffs, NY, 1984.
4. Leondes Cornelius T, "Computer Aided and Integrated Manufacturing Systems World Scientific", 2003.
5. William M Newman & Robert Sproul, "Principle of Interactice Computer Graphics", McGraw Hill, 1984.

ONLINE RESOURSE

1. Computer Aided Design and Manufacturing, NPTEL course, Prof. Anoop Chawla and Prof. P.V. Madhusudan Rao, IIT Delhi: https://nptel.ac.in/courses/112102101/
2. Computer Aided Engineering Design, NPTEL course by Prof. Anupam Saxena, IIT Kanpur: https://nptel.ac.in/courses/112104031/
3. "Computer Aided Design and Manufacturing" by Prof. Inderdeep Singh, IIT Delhi. (https://onlinecourses.nptel.ac.in/noc21_me86/preview)
4. "Finite Element Analysis" by Prof. K.M. Shorowordi, IIT Guwahati. (https://onlinecourses.nptel.ac.in/noc21_me82/preview)
5. "CAD and CAM" by Prof. S.K. Pal, IIT Kharagpur. (https://onlinecourses.nptel.ac.in/noc19_me21/preview)
6. "Introduction to CAD, CAM, and Practical CNC Machining" by Coursera (https://www.coursera.org/learn/cad-cam-cnc-machining)
7. "Finite Element Analysis (FEA) for Engineers" by Udemy (https://www.udemy.com/course/finite-element-analysis-fea-for-engineers/)
8. Finite Element Method, NPTEL course, Professor R. Krishna Kumar, IIT Madras: https://nptel.ac.in/courses/112106135/2.

IP-552 THEORY OF PRODUCTION PROCESSES-1 [3-0-0-3]

COURSE OUTCOMES

CO1. Learn and understand the fundamentals of melting and solidification of materials.
CO2. Understanding the basics of advanced casting and welding processes.
CO3. Applying the fundamentals of melting and solidification to understand the advanced casting and welding processes.
CO4. Analyze the effect of process parameters of different advanced casting and welding processes on the quality of cast and weld products respectively.
CO5. Learn and understand the fundamentals of welding automation and testing

DETAILED SYLLABUS

Basics of melting and solidification

Principles and applications of melting processes, Induction, Vacuum Arc, Skull, Plasma Arc and Electron Beam Melting. Melt processing: Principles of degassing, grain refining and modification. Basic concepts of solidification, Directional Solidification of single crystal and columnar-grained castings and its application to aerospace castings

Introduction to advanced casting processes

Evaporative Pattern Casting Process, Process Description of Evaporative Pattern Casting, Hybrid Evaporative Pattern Casting Process, Vacuum Sealed Moulding Process, Vacuum Sealed Moulding Process Set Up, Investment Casting Process, Ceramic Shell Investment Casting Process (CSIC), Wax Preparation, Blending and Process Parameters in CSIC, Shell Moulding, Processing Steps and Parameters in Shell Moulding, Low Pressure Gravity Die casting, Counter Gravity Sand Casting, and Squeeze Casting. Thixo-moulding and Resin-bonded moulding processes. Directional Solidification of single crystal and columnar-grained castings and its application to aerospace castings. Metal infiltration technology and Casting of Metal Matrix Composites, Micro-casting, Inert Environment Vacuum Casting and Solidification, Compocasting, Roll Casting, Casting of Intermetallic, and rapid sand casting

Introduction to advanced welding processes

Micro joining and nano joining, wire bonding; fundamentals and types of laser welding including hybrid processes, Laser properties; Stud welding and mechanical fasteners; Magnetically impelled arc welding; advanced gas tungsten arc welding; flux cored arc welding; electron beam welding; pressure welding; ultrasonic welding; explosive welding; diffusion bonding; friction stir welding; electromagnetic pulse welding; high velocity projectile impact welding

Fundamentals of welding automation and testing

Welding sensors and data acquisition; welding process modeling and optimization; computational welding mechanics for thermos-mechanical and microstructural phenomenon; principles of robotic welding; weld distortion and defects - causes and remedies; residual stresses; inspection and testing of weldments

TEXT BOOKS

1. Heine, R and Rosenthal P, "Principles of Metal Casting", Tata McGraw Hill, New Delhi 1980.
2. Metals Handbook, Vol.15, "Casting", ASM International, Metals Park, Ohio, 1988.
3. Yu, K O, "Modelling for Casting and Solidification Processing", Marcel Dekker, 2002.

4. Grong, O, "Metallurgical Modelling of Welding", Second Edition, The Institute of Materials, 1997.
5. Kou, S, "Welding Metallurgy", Second Edition, John Wiley Publications, New York, 2003.
6. Y N Zhou, "Microjoining and Nanojoining", Woodhead publishing, 2008.
7. W Steen, Laser Material Processing, Springer-Verlag, 1991.
8. L Liu, "Welding and Joining of Magnesium Alloys", Woodhead Publishing, 2010.
9. J Norrish, "Advanced welding Processes", Woodhead publishing, 2006.

REFERENCE BOOKS

1. Beeley, P, "Foundry Technology", Second Edition, Butterworth/Heinemann, 2001.
2. Kou, S, "Transport Phenomena in Materials Processing", John Wiley and Sons, 1996
3. "Materials and Processes in Manufacturing" (8th Edition), E P DeGarmo, J. T Black, R A Kohser, Prentice Hall of India, New Delhi (ISBN 0-02-978760).
4. "Manufacturing Science" A Ghosh, and A K Mallik, Affiliated East-West Press Pvt. Ltd. New Delhi.
5. "Non-traditional Manufacturing Processes", G F Benedict, Marcel Dekker, Inc. New York (ISBN 0-8247-7352-7).
6. American Welding Society, Welding Handbook, Section I to V" 8th Edition, 1996.
7. ASM International Handbook Committee, Welding, Brazing and Soldering, ASM handbook, Vol 6, 1993.
8. Nadkarni,S V, "Modern Arc welding techniques handbook", Oxford IBH, 1988.
9. L E Lindgren, "Computational welding mechanics", Woodhead Publishing Limited 2007.
10. J A Goldak, "Computational welding mechanics", Springer, 2005

ONLINE RESOURSES

1. Advanced Manufacturing Processes, NPTEL course, Dr. Pradeep Kumar and Dr. A. K. Sharma, Department of Mechanical and Industrial Engineering, IIT Roorkee. http://nptel.ac.in/syllabus/112107077/
2. Advances in Welding and Joining Technologies, NPTEL course, Dr.Swarup Bag, IIT Guwahati. https://onlinecourses.nptel.ac.in/noc18me20/

IP-553 ADDITIVE MANUFCTURING [3-0-0-3]

COURSE OUTCOMES:

At the end of the course, student will be able to:
CO1. Understand the working principle and process parameters of AM processes
CO2. Select the Suitable process for Fabricating a Given Product
CO3. Know about the different file formats used in AM
CO4. Use suitable post processes based on product application
CO5. Explore the applications of AM processes in various fields

DETAILED SYLLABUS:

Introduction to Additive Manufacturing (AM): Need for Additive Manufacturing, Generic AM process, Distinction between AM and CNC, Classification of AM Processes, Steps in AM process, Advantages of AM

Design for Additive Manufacturing (DfAM): Need for Design for Additive Manufacturing (DfAM), General Guidelines for DfAM, Role of Build Orientation, Slicing, Toolpath Selection, Different Types of Support Structures

Different File Formats for AM: STL File Formats, STL Errors, STL Repairing Algorithms, AMF format, OBJ, AMF, and 3MF, advantages and drawbacks

Software for AM: Preparation of CAD Models, Software for CAD Modelling, STL Repairing Software, Additional Software to Assist AM, Internet-based Software.

Overview of AM processes: Vat Photopolymerization AM Processes, Material Jetting AM Processes, Binder Jetting AM Processes, Extrusion-Based AM Processes, Sheet Lamination AM Processes, Powder Bed Fusion AM Processes, Directed Energy Deposition AM Processes, Process Benefits and Drawbacks, Applications.

Post Processing of AM Parts: Support Material Removal for Polymer and Metal Based AM, Surface Texture Improvement, Accuracy Improvement, Aesthetic Improvement, Property Enhancements using Non-thermal and Thermal Techniques.

Guidelines for Process Selection: Introduction, Selection Methods for a Part, Challenges of Selection, Example System for Preliminary Selection, Material Selection.

Reverse Engineering and Rapid Tooling: Reverse Engineering Geometric data acquisition, 3D reconstruction, Tools for Reverse Engineering, Introduction to RT, Indirect RT Processes: -Silicon Rubber Molding, Epoxy Tooling, Spray Metal Tooling and Investment Casting. Direct RT Processes: -Laminated Tooling, Powder Metallurgy-Based Technologies Welding Based Technologies, Direct Pattern Making, Emerging Trends in RT.

AM Applications: Functional Models, Pattern for Investment and Vacuum Casting, Medical models, Art models, Engineering Analysis Models, Multifunctional Printing, Bio-Printing, Application examples for Aerospace, defence, automobile, Bio-medical and general engineering industries.

Quality Control and Testing in Additive Manufacturing: Inspection techniques for AM parts, Non-destructive testing methods, Evaluation of dimensional accuracy, surface quality, and mechanical properties.

Special Topics on AM: 4D Printing, Programming in AM, Overview of the algorithms used in AM

TEXT BOOKS

1. Ian Gibson, David W Rosen, Brent Stucker, "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing", 2nd Edition, Springer, 2015.
2. Chua Chee Kai, Leong Kah Fai, "3D Printing and Additive Manufacturing: Principles& Applications", 4th Edition, World Scientific, 2015.

IP-554 SURFACE ENGINEERING [3-0-0-3]

COURSE OUTCOMES

CO1. Understand failure micro mechanisms occurring for different service conditions.
CO2. Understand the fundamentals and applications of tribological theories
CO3. Understand the fundamentals and applications of lasers in surface engineering problems
CO4. Identify appropriate testing approaches to evaluate service performance.
CO5. Analyze real life surface failure problems and determine the correct surface engineering solution by applying contact mechanics.

DETAILED SYLLABUS

Fundamentals of surface engineering
Introduction and need of surface engineering, surface/sub-surface regions. Thermodynamics of surface, surface dependent engineering properties, common surface initiated engineering failure; mechanism of surface degradation. Surface engineering: classification, definition, scope and general principles.

Tribology
Friction: mechanisms and types, controlling friction. Wear: nature, mechanism and types, wear testing. Lubrication: lubrication regimes, hydrodynamic and hydrostatic lubrication, lubricants: characterization, types and effects, lubrication and bearings, properties and testing of lubricants. Corrosion, classification, corrosion prevention.

Sputter deposition techniques
Surface coating by chemical routes: Chemical vapor deposition (CVD), laser assisted chemical vapor deposition. Surface coating by physical routes: physical vapor deposition (PVD), pulsed laser deposition, cathodic arc evaporation

Surface Coating by Wetting
Concept of surface energy, Structure and types of interfaces, surface energy and related equations. Mechanism of wetting, Coatings on ceramics by wetting, Coating of monolayer abrasive grain by wetting

Surface engineering by thermal spraying
Principle and scope of application: Flame spray; Atmospheric Plasma Spraying (APS), Vacuum Plasma Spraying (VPS), Detonation-Gun Spraying (D-GUN), High-Velocity Oxy-Fuel (HVOF) Spraying, Cold spraying.

Laser surface engineering
Laser transformation hardening, Laser remelting, Laser alloying, Laser cladding, Laser ablation, Pulsed laser deposition, Laser doping, Laser crystallization, Laser surface texturing, Laser shock peening

Characterization of coatings and surfaces
Physical Characterization: Assessment of Coatings Thickness; Porosity, Density & Adhesion Strength, Coating Hardness, Assessment of Friction and Wear of Coating, Assessment of Surface Roughness, Surface microscopy & topography by scanning probe microscopy; Spectroscopic analysis of modified surfaces

TEXT BOOKS

1. Tadeusz Burakowski, Tadeusz Wierzchon, "Surface Engineering of Metals-Principles, equipment and technologies", CRC Press, 1999.

2. Lech Pawlowski, "The Science and Engineering of Thermal Spray Coatings", 2nd Edition, John Wiley & Sons, 2008.
3. Ohring M, The Materials Science of Thin Films, Academic Press Inc, 2005.
4. Martin P., "Introduction to Surface Engineering and Functionally Engineered Materials", John Willey, 2011.
5. William M. Steen, Jyotirmoy Mazumder, "Laser Material Processing", 4th Edition, Springer Verlag, 2010.

REFERENCE BOOKS

1. Boolga M K, "Surface Engineering and Applied Electrochemistry", Springer.
2. Budinski K G, Surface Engineering for Wear Resistances, Prentice Hall, Englewood Cliffs, 1988.
3. William M Steen, Jyotirmoy Mazumder, "Laser Material Processing", 4th Edition, Springer Verlag, 2010.
4. Devis, J R, "Surface Engineering for Corrosion & Wear Resistance", 2001, Maney Publishing.

ONLINE RESOURSES

1. Surface Engineering for Corrosion and Wear Resistance Applications, NPTEL Course by prof Indranil Manna & Prof Jyotsna D Majumder, IIT Kharagpur: https://nptel.ac.in/courses/113/105/113105086/
2. Technology of Surface Coating, NPTEL course, Prof. A.K. Chattopadhyay, IIT Kharagpur: https://nptel.ac.in/courses/112105053/
3. Fundamentals of Surface Engineering: Mechanisms, Processes and Characterizations, NPTEL course, – By D K Dwivedi, IIT Roorkee, https://nptel.ac.in/courses/112107248/
4. NPTEL course: Soft Nano Technology by Prof Rabibrata Mukherjee, IIT Kharagpur; https://nptel.ac.in/courses/103/105/103105122/

IP-555 MACHINE LEARNING-I [3-0-0-3]

COURSE OBJECTIVE

This course intends to train the students in various concepts and methods of Data analysis like Regression, classification, clustering, dimensionality reduction and to make them industry ready to take up Data analyst jobs.

COURSE OUTCOMES

CO1. The students will learn, understand and will be able to apply the basic commands of python for data analytics

CO2. The students will learn, understand and will be able to apply data extraction, visualization and normalization techniques using various libraries of python.

CO3. The students will be able to define and differentiate among various concepts and techniques of data analytics

CO4. The students will be able to list, understand, differentiate and apply various regression and classification algorithms of Supervised Learning,

CO5. The students will be able to list, understand, differentiate and apply various clustering algorithms of Un-Supervised Learning

CO6. The students will be able to analyze a complex real life case situation, choose or design the appropriate algorithm to solve it, construct the model using appropriate programming technique, solve the same and interpret the results.

CO7. The students will be able to apply multiple models in a given situation, evaluate and compare their prediction accuracies and choose the best model.

DETAILED SYLLABUS

SECTION A

Review of Linear algebra and probability

Concept of statistics, measure of central tendency and dispersion, coefficient of dispersion, moments, factorial moments, skewness and kurtosis.

Different approaches to probability, addition and multiplication theorem of probability, Conditional probability, Bayes theorem and applications. Random variables – discrete and continuous, distribution function, probability mass function, probability density function, two dimensional random variables, mathematical expectation, expectation of discrete and continuous random variables, properties of expectation, conditional expectation. Discrete and Continuous Probability Distributions: Hyper-geometric, Binomial, negative Bi-nomial, Poisson, Normal, Exponential, log-normal distribution

Introduction to vectors, modulus, inner product, dot product, projection, vector space and linear independence, solving simultaneous equations, orthogonal matrices, Eigen value, Eigen vectors,

Machine Learning

Types of Learning: Supervised Learning, Classification vs. Regression, Un- Supervised Learning, Derivative and Gradient, Bias- Variance dichotomy, Hyper parameter Tuning, Cross-Validation, Handling Imbalanced Datasets

Data pre-processing: Normalization, one hot encoding, handling missing values, dimensionality reduction, PCA, LDA, Outlier Detection

SECTION B

Basic Python commands

Print command, input commands, looping statements, conditional statements, important functions in python: string functions, time functions, random functions, user defined functions, local and global variables, threading, data structures in python: List, Tuples, Dictionary, features and usage of various libraries like matplotlib, numpy, pandas, sklearn, data transfer between excel files and numpy/pandas arrays, plotting line graphs, bar charts, scatter diagrams and pie charts using matplotlib, data manipulation operations on arrays, various types of join operations, linking python with SQL for data sharing.

Supervised Learning

Regression

Regression: simple and multiple linear regression, polynomial regression Ordinary Least Squares method, Gradient descent method, Regularization: Ridge Regression, Lasso Regression, role of scatter plots in parameters selection, Nearest Neighbours Regression, Bias-Variance Dichotomy, Model Validation Approaches, Decision Trees Regression, Random Forest Regression, Support Vector Regression,

SECTION C

Classification

Classification: maximum likelihood approach, Sigmoid Function, Logistic Regression, Train-Test- Validate data, Decision tree classification, entropy minimization approach, Ginni's imperfection, Support Vector Machines, Kernel functions, KNN classification, cosine similarity, Naive Bayes Classification, Ensemble Methods: Random Forest, Model Performance Assessment: Confusion matrix, Accuracy, Cost-sensitive accuracy, Precision/recall, Mathew's correlation co-efficient, Area under the ROC curve,, visualizing the decision boundaries using Meshgrids and contour plots

Unsupervised Learning

Clustering

Difference between agglomerative and divisive clustering techniques, K-Means Clustering, WCSS, elbow and Dendrograms methods to find optimal number of clusters, visualizing clusters using scatter plots.

TEXT BOOKS

1. Andriy Burkov, "The Hundred-Page Machine Learning Book"
2. Ethem Alpaydin, Introduction to Machine Learning, 4th edition, MIT Press 2020
3. Tom M. Mitchell, Machine Learning, McGraw-Hill Education (India) Private Limited, 2013.
4. Levin & Rubin, "Statistics for Management" 7th Edition, Pearson Education Singapore.
5. Sukhminder Singh, M.L. Bansal" Statistical methods for research workers" Kalyani Publishers

6. K. Hoffman and R. Kunze, "Linear Algebra", Prentice Hall

REFERENCE BOOKS

1. Stephen Marsland, Machine Learning: An Algorithmic Perspective, CRC Press, 2014.
2. Zhi-Hua Zhou, Ensemble Methods: Foundations and Algorithms, CRC Press, 2012

ONLINE RESOURSES

Introduction to Data Analytics, NPTEL course, Prof. Nandan Sudarsanam and Prof. Balaraman Ravindran Deptt.of Management Studies, IIT Madras, http://nptel.ac.in/courses/110106064
StatQuest; https://www.youtube.com/@statquest

IP-595 COMPUTER AIDED ENGINEERING AND MACHINE LEARNING LAB [0-0-3-2]

COURSE OUTCOMES

At the end of the course the students are expected to

CO1. Gain proficiency in Computer-Aided Design (CAD) software and apply it to create 3D models of mechanical parts and assemble complex systems.
CO2. Understand the principles and applications of Computer-Aided Manufacturing (CAM) software, including generating tool paths and programming CNC machines for milling and turning operations.
CO3. Develop skills in Finite Element Analysis (FEA) and utilize FEA software to analyze stress, deformation, and thermal behavior in mechanical components and systems.
CO4. Acquire knowledge of Machine Learning (ML) algorithms and techniques and apply them to real-world problems, such as binary classification, image classification, regression analysis, or clustering.
CO5. Integrate CAD, CAM, FEA, and ML technologies to solve engineering challenges and optimize design, manufacturing, and analysis processes.
CO6. Develop critical thinking and problem-solving skills through hands-on experimentation and analysis of engineering data using CAD, CAM, FEA, and ML tools.

LIST OF EXPERIMENTS

CAD

1. Creating a 3D model of a mechanical part: In this experiment, students can be tasked with creating a 3D model of a simple mechanical part using CAD software. They can learn the basics of 3D modeling, including creating sketches, extruding, and creating chamfers and fillets. Once they have modeled the part, they can assemble it with other parts and create an exploded view to show how the parts fit together.

2. Designing and assembling a robotic arm: Students can be challenged to design and assemble a robotic arm using CAD software. They can start with creating sketches of the arm's different components and then use the software to create 3D models. They can then assemble the arm and simulate its movement to check for any design flaws.

CAM

1. CNC Machining Experiment: This experiment involves using CAM software to generate tool paths for milling and turning operations and then programming a CNC machine to produce a physical part based on those tool paths.

2. Post-processing and Simulation Experiment: In this experiment, CAM software is used to post-process tool paths and simulate machining operations to check for errors and optimize the process.

FEA

1. Analysis of stress and deformation of a cantilever beam: Use FEA software to simulate the behavior of a cantilever beam under various loads and boundary conditions, and analyze the stress and deformation in the beam.

2. Thermal analysis of a heat sink: Use FEA software to simulate the heat dissipation of a heat sink and analyze its thermal performance under various operating conditions.

3. Dynamic analysis of a mechanical system: Use FEA software to simulate the dynamic behaviorof a mechanical system, such as a rotating shaft, and analyze its response to various loads and operating conditions.

ML

1. Generative Design Optimization using ML
   - Develop an ML model to optimize the design parameters of a mechanical component.
   - Integrate the ML model with CAD software to automate the design process.
   - Compare the performance of the optimized design with traditional design methods.
2. Simulation-Based Optimization using ML
   - Utilize CAE tools to simulate and analyze the performance of a complex system.
   - Train an ML model to optimize the system parameters based on simulation results.
   - Validate the optimized parameters using physical prototypes or further simulations.
3. Intelligent Robotics using ML and CAD
   - Design and model a robotic system using CAD software.
   - Develop ML algorithms to enable the robot to perceive and interact with its environment.
   - Implement the ML algorithms on a physical robot and evaluate its performance.
4. Material Property Prediction using ML
   - Gather a dataset of material properties (e.g., strength, conductivity) for different materials.
   - Train ML models to predict material properties based on composition or microstructure.
   - Integrate the ML models into a CAD system to assist in material selection and design.
5. Optimization of CNC Machining Parameters using ML
   - Collect data on machining parameters (e.g., feed rate, cutting speed) and corresponding outcomes.
   - Apply ML techniques to model the relationship between parameters and machiningquality.
   - Use the ML model to optimize machining parameters for improved efficiency andaccuracy.

TEXT BOOKS

1. Ibrahim Zeid, "CAD/CAM Theory and Practice", McGraw-Hill, 1991.
2. Mortenson, M E, Geometric Modelling, John Wiley and Sons, NY, 1991.
3. "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville
4. Finite Element Analysis: Theory, Application, and Implementation by M. Asghar Bhatti, 2nd Edition, 2019.
5. "Introduction to Autonomous Robots: Kinematics, Perception, Localization, and Planning" by Nikolaus Correll, Bradley Hayes, and George A. Kantor
6. "Introduction to CAD/CAM/CAE: A Computer-Aided Design and Manufacturing Perspective" by Ibrahim Zeid
7. "Introduction to Robotics: Mechanics and Control" by John J. Craig
8. "Machine Learning: A Probabilistic Perspective" by Kevin P. Murphy
9. "Pattern Recognition and Machine Learning" by Christopher M. Bishop
10. Reddy,J N., ―Introduction to Finite Element Method‖, McGraw Hill, 1993
11. Machining and CNC Technology by Michael Fitzpatrick and Steve Krar, 3rd Edition, 2020.

REFRENCE BOOKS

1. "CAD/CAM: Theory and Practice" by Ibrahim Zeid
2. "Finite Element Method: Basic Concepts and Applications" by Chandrupatla and Belegundu

3. "Learning OpenCV: Computer Vision with the OpenCV Library" by Gary Bradski andAdrian Kaehler
4. "Machine Learning: The Art and Science of Algorithms that Make Sense of Data" byPeter Flach
5. "Reinforcement Learning: An Introduction" by Richard S. Sutton and Andrew G. Barto

ONLINE RESOURSE

1. Computer Aided Design and Manufacturing, NPTEL course, Prof. Anoop Chawla andProf. P.V. Madhusudan Rao, IIT Delhi: https://nptel.ac.in/courses/112102101/
2. Computer Aided Engineering Design, NPTEL course by Prof. Anupam Saxena, IIT Kanpur: https://nptel.ac.in/courses/112104031/
3. "Computer Aided Design and Manufacturing" by Prof. Inderdeep Singh, IIT Delhi. (https://onlinecourses.nptel.ac.in/noc21_me86/preview)
4. "Finite Element Analysis" by Prof. K.M. Shorowordi, IIT Guwahati. (https://onlinecourses.nptel.ac.in/noc21_me82/preview)
5. "CAD and CAM" by Prof. S.K. Pal, IIT Kharagpur. (https://onlinecourses.nptel.ac.in/noc19_me21/preview)
6. "Introduction to CAD, CAM, and Practical CNC Machining" by Coursera (https://www.coursera.org/learn/cad-cam-cnc-machining)
7. "Finite Element Analysis (FEA) for Engineers" by Udemy (https://www.udemy.com/course/finite-element-analysis-fea-for-engineers/)
8. Finite Element Method, NPTEL course, Professor R. Krishna Kumar, IIT Madras: https://nptel.ac.in/courses/112106135/2.

IP-596 MANUFACTURING LAB-I [0-0-3-2]

COURSE OBJECTIVE

To make students aware of the consideration and practical aspects of welding and casting technology.

COURSE OUTCOME

At the end of the course, students will be able to

CO1. Operate the experimental setups and perform the welding and casting experiments.

CO2. Select the process parameters of the welding and casting processes, and analyze their influence on the properties of the fabricated materials.

CO3. Analyze the microstructures of the ferrous and non-ferrous metals.

CO4. Evaluate the microstructure and properties relationship of the fabricated materials obtained through welding and casting processes.

LIST OF EXPERIMENTS:

1. To perform Arc striking practice and Bead-on-plate welding
2. To analyze the variation in process parameters such as welding current, voltage, wire feed rate etc. on different output parameters for Tungsten Inert Gas welding System.
3. To study and analyze the process parameters such as welding current, voltage, wire feed rate etc. on different output parameters for Metal Inert Gas welding System.
4. To study and analyze the process parameters such as welding current, voltage, wire feed rate etc. on different output parameters for Submerged Arc Welding System.
5. To study and analyze the process parameters for Friction stir welding of Aluminum.
6. To study and analyze the process parameters for Spot welding unit.
7. Microstructural observation of weldments of Carbon steel, Stainless steel and Aluminum.
8. To prepare a sample of casting by varying process parameters using Injection Molding Machine.
9. To prepare a sample of composite casting by varying process parameters using stir casting process.
10. To study and analyze the variation in microstructure of casting sample by varying process parameters for sand casting process.

REFERENCE BOOKS

1. Heine, R and Rosenthal P., "Principles of Metal Casting", Tata McGraw Hill, New Delhi 1980.
2. Metals Handbook, Vol.15, "Casting", ASM International, Metals Park, Ohio, 1988.
3. Yu, K O, "Modelling for Casting and Solidification Processing", Marcel Dekker, 2002.
4. Grong, O, "Metallurgical Modelling of Welding", Second Edition, The Institute of Materials, 1997.
5. Kou, S, "Welding Metallurgy", Second Edition, John Wiley Publications, New York, 2003.
6. L Liu, "Welding and Joining of Magnesium Alloys", Woodhead Publishing, 2010.
7. J Norrish, "Advanced welding Processes", Woodhead publishing, 2006.

8. A. Ghosh, and A K Mallik, "Manufacturing Science", Affiliated East-West Press Pvt. Ltd. New Delhi.
9. American Welding Society, "Welding Handbook, Section I to V" 8th Edition, 1996.
10. Nadkarni,S V, "Modern Arc welding techniques handbook", Oxford IBH, 1988.
11. L E Lindgren, "Computational welding mechanics", Woodhead Publishing Limited 2007.

ONLINE RESOURSES

1. Advanced Manufacturing Processes, NPTEL course, Dr. Pradeep Kumar and Dr. A. K. Sharma, Department of Mechanical Engineering, IIT Roorkee. http://nptel.ac.in/syllabus/112107077/
2. Advances in Welding and Joining Technologies, NPTEL course, Dr.Swarup Bag, IIT Guwahati. https://onlinecourses.nptel.ac.in/noc18_me20/

IP-556 INDUSTRIAL INTERNET OF THINGS [3-0-0-3]

COURSE OUTCOMES

CO1. Understand the fundamental concepts and principles of the Industrial Internet of Things (IIoT), including the integration of physical devices, sensors, and actuators with network connectivity.
CO2. Identify and analyze the various components and technologies involved in IIoT systems, such as embedded systems, wireless communication protocols, data analytics, and cybersecurity.
CO3. Apply knowledge of networking protocols, such as MQTT and CoAP, to enable seamless communication and data exchange between IIoT devices, gateways, and cloud platforms.
CO4. Evaluate and select appropriate sensors, actuators, and communication technologies based on specific industrial requirements, considering factors such as reliability, scalability, power consumption, and data transmission rates.
CO5. Design and develop IIoT applications and solutions for industrial automation, predictive maintenance, real-time monitoring, and optimization of industrial processes.

DETAILED SYLLABUS

Introduction to IIoT

Define IoT and its impact on society, embedded system is and its components, interaction between software and hardware in an IoT device, role of an operating system in supporting software in an IoT device. Introduce the Arduino and Raspberry Pi platforms and their use in IoT devices, sensors and actuators in IIoT.

Networking for IIoT

Basic Characteristics of Computer network, Elements of Network Communication Protocols, OSI Model, IPv4 and IPv6, network topologies, IEEE 802 standard, Mobile AdHoc Network (MANET), IoT Network quality of service, MQTT and CoAP communication protocols, Serial communication methods, I2C, SPI and UART. Describe the use of networking and basic networking hardware.

Arduino Platform and Programming

Composition of the Arduino development board, pinout diagram and datasheet of Arduino Uno. Installation of the Arduino IDE and compile/run sample sketches, Use embedded C programming language to write sketches for the Arduino, Simulate integration of various sensors and actuators with Arduino Uno on Tinkercad platform. Develop Arduino Uno based real world novel applications using Arduino-specific shields and software libraries.

Raspberry Pi Platform and Programming

Set up the Raspberry Pi environment and get a Linux operating system running, Use Python programming language to write code for the Raspberry Pi, Learn how to use Python-based IDEs for the Raspberry Pi and how to trace and debug Python code on the device. Interface the Raspberry Pi with more complicated sensors and actuators. Explore the use of the Raspberry Pi camera module and servos.

Design, build, and test a microcontroller-based embedded system on a low-cost budget for a real-

world application.

TEXTBOOKS

1. "Arduino for Dummies" by John Nussey
2. "Programming the Raspberry Pi: Getting Started with Python" by Simon Monk
3. "Learning Python with Raspberry Pi" by Alex Bradbury and Ben Everard

REFERENCE BOOKS

1. "Building the Internet of Things: Implement New Business Models, Disrupt Competitors, Transform Your Industry" by Maciej Kranz (2nd Edition, 2021)
2. "Designing Connected Products: UX for the Consumer Internet of Things" by Claire Rowland, Elizabeth Goodman, Martin Charlier, and Ann Light (2nd Edition, 2021)
3. "The Fourth Industrial Revolution" by Klaus Schwab (2017)
4. "Industry 4.0: The Industrial Internet of Things" by Alasdair Gilchrist (1st Edition, 2016)
5. "IoT Inc: How Your Company Can Use the Internet of Things to Win in the Outcome Economy" by Bruce Sinclair (1st Edition, 2017)

ONLINE RESOURCE

1. "Introduction to the Internet of Things and Embedded Systems" by Professor Ian Harris, University of California, Irvine on Coursera.https://www.coursera.org/learn/iot-foundations
2. "The Internet of Things" by Professor Greg Benson, University of San Francisco on Coursera: https://www.coursera.org/learn/iot/home/welcome
3. "Introduction to the Internet of Things (IoT)" by IBM on Coursera: https://www.coursera.org/learn/internet-of-things
4. "Getting Started with the Internet of Things (IoT)" by Intel on edX: https://www.edx.org/course/getting-started-with-the-internet-of-things-iot
5. "Embedded Systems - Shape The World: Microcontroller Input/Output" by Professor Jonathan Valvano, University of Texas at Austin on edX: https://www.edx.org/course/embedded-systems-shape-the-world-microcontroller-i
6. "Introduction to Cybersecurity for the Internet of Things" by IBM on edX: https://www.edx.org/course/introduction-to-cybersecurity-for-the-internet-of-t

NPTEL COURSES

1. Industrial Internet of Things - Dr. S. V. Kasmir Raja: https://onlinecourses.nptel.ac.in/noc21_ee32
2. Introduction to Industrial Internet of Things - Dr. Samarjit Sengupta: https://onlinecourses.nptel.ac.in/noc21_ee13
3. Industrial IoT Fundamentals - Dr. R. Senthil Kumar: https://onlinecourses.nptel.ac.in/noc21_ee40
4. IoT for Smart Manufacturing - Dr. S. S. Pande: https://onlinecourses.nptel.ac.in/noc20_mm31
5. IoT and Sensor Based Industrial Automation - Dr. S. S. Pande: https://onlinecourses.nptel.ac.in/noc20_mm30

IP-557 INDUSTRIAL AUTOMATION AND ROBOTICS [3-0-0-3]

COURSE OUTCOME

CO1. Identify and select appropriate hydraulic and pneumatic circuits for different applications
CO2. Apply electro-hydraulic/pneumatic controls to control hydraulic and pneumatic systems
CO3. Develop and program PLCs to automate industrial processes
CO4. Understand the kinematics, dynamics, and control of industrial robots
CO5. Program robots for different applications

DETAILED SYLLABUS

Industrial Automation

The need for automation and a comparison of hydraulic and pneumatic systems
ISO symbols for fluid power elements and selection criteria for hydraulic and pneumatic systems
Characteristics and construction of linear actuators, as well as selection and specification of hydraulic system components
Reservoir capacity, heat dissipation, and accumulators in hydraulic systems
Standard circuit symbols and circuit analysis for hydraulic circuits, including direction, flow, and pressure control valves and electro hydraulic servo valves
Design methodology for typical industrial hydraulic circuits, including ladder diagrams and combinatorial logic circuits
Electrical control of pneumatic and hydraulic circuits using relays, timers, counters, and ladder diagrams
Programmable logic control of hydraulics and pneumatics circuits, including sensors, PLC ladder diagrams, and motion controllers, as well as the use of field buses in circuits
Electronic drive circuits for various motors

Robotics

Fundamentals of robotics: This includes the design of robot wrists, end effectors, and actuators. The concept of modular robots is also covered in this section.
Robot and its peripherals: This section covers the different sensors used in robotics, including machine vision and image processing and analysis. It also explores the application of artificial intelligence in robotics, as well as voice communication and robot control units.
Robot kinematics: This section covers homogeneous transformations, forward and inverse kinematics, problems of dynamics, differential relationships, motion trajectories, dynamics of a robot control of single and multiple link robots, and static force analysis.
Robot programming: Different programming languages for robotics and expert systems are covered in this section.

TEXT BOOKS

1. Esposito, A. (2022). Fluid power systems and control (5th ed.). Pearson.
2. Craig, J. J. (2019). Introduction to robotics: mechanics and control (4th ed.). Pearson.
3. Bolton, W. (2015). Pneumatic and Hydraulic Systems. Butterworth-Heinemann.
4. McComb, G. (2015). Robot builder's bonanza (5th ed.). McGraw-Hill Education.

REFERENCE BOOKS

1. W. Bolton, "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering," Pearson Education, 2015

2. Peter Rohner, "Fluid Power Logic Circuit Design," The Macmillan Press Ltd., 1982
3. Dudbey A. Peace, "Basic Fluid Power," Prentice Hall, 2002
4. Quigley, M., Gerkey, B., & Smart, W. D. (2019). Programming robots with ROS: a practical introduction to the Robot Operating System (2nd ed.). O'Reilly Media, Inc.
5. Siciliano, B., & Sciavicco, L. (2020). Robotics: modelling, planning and control (2nd ed.). Springer.

ONLINE RESOURSES

NPTEL courses related to Industrial Automation and Robotics:

1. Introduction to Robotics: This course covers the basic concepts of robotics, kinematics, control, and programming. It also covers different types of robots and their applications. The course is taught by Prof. S.K. Saha from IIT Delhi.
2. Industrial Automation and Control: This course covers the principles of automation, sensors and actuators, programmable logic controllers (PLCs), human-machine interface (HMI), and industrial control systems. The course is taught by Prof. S. Mukhopadhyay from IIT Kharagpur.
3. Automation in Manufacturing: This course covers the various aspects of automation in manufacturing, such as sensors and actuators, PLCs, SCADA systems, robotics, and CIM (Computer-Integrated Manufacturing). The course is taught by Prof. S.K. Saha from IIT Delhi.
4. Mechatronics: This course covers the basics of mechatronics, such as sensors and transducers, actuators, control systems, and programming. It also covers the integration of mechanical, electrical, and electronic systems. The course is taught by Prof. R. Muthukumar from IIT Madras.
5. Advanced Robotics: This course covers advanced topics in robotics, such as robot control architectures, motion planning, vision-based control, and multi-robot systems. The course is taught by Prof. K. Madhava Krishna from IIT Madras.

IP-558 THEORY OF PRODUCTION PROCESSES-II [3-0-0-3]

COURSE OUTCOMES

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

CO1. Learn and understand the different metal forming processes

CO2. Understand the application of the fundamental principles of metallurgy to the metal forming processes.

CO3. Understand the basic mechanics of metal forming as applied to rolling, forging, extrusion and sheet metal operations.

CO4. Apply the principles of metallurgy and mechanics to solve forming design problems.

CO5. Analyze the advanced forming processes based upon existing mechanics and metallurgy.

DETAILED SYLLABUS

Introduction to Metal Forming: Metallurgical aspects of metal forming, slip, twinning mechanics of plastic deformation, effects of temperature, strain rate, microstructure and friction in metal forming-yield criteria and their significance, Classification of Metal Forming Processes, Stress strain relations in elastic and plastic deformation, concept of flow stresses, deformation mechanisms, Hot and Cold Working Processes and their effect on mechanical properties.

Rolling: Types of Rolling Mills, Forces and Geometrical Relationships in Rolling, Calculation of Rolling Load, Roll Pass Design, Defects in Rolled Products. Other Related Processes like Roll Piercing, Ring Rolling, Pipe and tube production by rolling processes, Contour roll forming.

Forging: Operation and principle of Forging Processes and Equipment, Methods of forging, Open and Close Die Forging Processes, Defects, Structure and Properties of Forged Products. Force Analysis in forging. Other Related Processes like Cold Heading, Rotary Swaging, Sizing, Coining, Embossing and Roll Forging, P/M forging, Isothermal forging-high speed.

Extrusion: Extrusion Equipment, Forces in extrusion, Analysis of Extrusion Process, Extrusion of components including Seamless Pipes and Tubes. Extrusion of pipes by cold working, Wire Drawing, Rod Drawing, Tube Drawing, Deep Drawing, Analysis of Wire Drawing Process and Load Calculations Other Related Processes like Impact Extrusion, Hydrostatic Extrusion, Piercing, cupping and bending.

Sheet Metal Forming: Principle, process parameters, equipment and application of the following processes: spinning, stretch forming, plate, V and edge bending, Curling, Ironing, Roll Bending, Metal Spinning. Press brake forming, Explosive forming, Hydro forming, Electro-hydraulic forming, and magnetic pulse forming. High Velocity forming of metals and High energy Rate forming, Electro forming.

TEXT BOOKS

1. Hosford W F and Caddell, R M, "Metal Forming Mechanics and Metallurgy", Prentice Hall,1983.
2. Scrope Kalpakjian, "Manufacturing processes for Engineering Materials", Addision Wesley, 1997.
3. George E. Dieter, "Mechanical metallurgy", Mc Graw Hill, 2016.

ONLINE RESOURCES

1. Mechanics Of Metal Forming, NPTEL course, Professor Pradeep K. Jha, IIT Roorkee: https://archive.nptel.ac.in/courses/112/107/112107250/.

IP-559 HIGH PRECISION MANUFACTURING [3-0-0-3]

COURSE OUTCOMES

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

CO1. To understand and classify micro and nano manufacturing processes
CO2. To apply the material removal processes for micro and nano machining/finishing
CO3. To analyze various additive and subtractive Nano fabrication techniques
CO4. To evaluate the accuracy and precision of the fabricated micro/nano components.

DETAILED SYLLABUS

Introduction to meso, micro and nano manufacturing- miniaturization and applications – micro-manufacturing – classification – micro-machining: concepts and significance theory of micro-machining – chip formation -size effect in micro-machining.

Electric discharge micro-machining, ultrasonic micro-machining, laser beam micro-machining, elastic emission micro machining, focused ion beam micromachining.

Abrasive flow finishing, magnetic abrasive finishing, magnetorheological finishing, magnetorheological abrasive flow finishing, magnetic float polishing; Hybrid finishing processes-chemo mechanical polishing, electro discharge grinding, Electrochemical grinding.

Chemical vapor deposition (CVD), Physical vapor deposition (PVD), Lithography, Dry etching, Wet etching

Inspection and metrology for micro machined components - optical microscopy, white light interferometry, micro CMM, scanning probe microscopy – scanning electron microscope, transmission electron microscope, atomic force microscope.

TEXT BOOKS

1. Jain, V.K "Introduction to Micro-machining", Narosa publishing house, ISBN: 978-81-7319-915-8, 2010.
2. Jain, V.K, "Micro-manufacturing Processes", by CRC Press, ISBN: 9781439852903,
3. 2012.
4. Madou, M.J., "Fundamentals of Micro-fabrication: The science of miniaturization", CRC Press, 2006.
5. Mcgeoug.J.A., "Micromachining of Engineering Materials", CRC Press, 2001.
6. Dorfeld, David & Lee, Dae-Eun, "Precision Manufacturing", Springer, 2008
7. Kalpakjian.S, "Manufacturing Engineering and Technology", Pearson Education, 2001

ONLINE RESOURCES

1. Advance machining process, NPTEL course, Professor V K Jain, IIT Kanpur: https://archive.nptel.ac.in/courses/112/104/112104028/
2. Fundamentals of micro and nanofabrication, NPTEL course, Prof. Shankar Selvaraja, IISc Bangalore, https://archive.nptel.ac.in/courses/117/108/102108078/

IP-560 MACHINE LEARNING-II [3-0-0-3]

COURSE OBJECTIVE

This course intends to train the students in various concepts of deep learning like artificial neural networks, convolutional neural networks and recurrent neural networks and to make them industry ready to take up AI jobs.

COURSE OUTCOMES

CO1. The students will learn about history of development of deep learning and its present state of art.
CO2. The students will learn, understand and will be able to apply various state of art architectures like AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet
CO3. The students will be able to learn, understand and will be able to apply various parameter learning approaches, their advantages and shortcomings
CO4. The students will be able to learn and understand various techniques for faster convergence of deep learning models.
CO5. The students will be able to list, understand, differentiate and apply various time series models

DETAILED SYLLABUS

SECTION A

History:
History of Deep Learning, Deep Learning Success Stories, McCulloch Pitts Neuron, Thresholding Logic, Perceptrons, Perceptron Learning Algorithm and Convergence, Multilayer Perceptrons (MLPs), Representation Power of MLPs

Understanding current scenario:
Sigmoid Neurons, Gradient Descent, Feedforward Neural Networks, Representation Power of Feedforward Neural Networks, and Feedforward Neural Networks

Techniques for Parameter Training:
Backpropagation, and Computation Graphs, Gradient Descent (GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, AdaGrad, RMSProp, Adam

SECTION B

Auto Encoders:
Eigenvalues and eigenvectors, Eigenvalue Decomposition, Basis, Principal Component Analysis and its interpretations, Singular Value Decomposition, Autoencoders and relation to PCA, Regularization in autoencoders, Denoising autoencoders, Sparse autoencoders, Contractive autoencoders

Regularization:
Bias Variance Trade-off, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout

Techniques for Faster Convergence:

Greedy Layerwise Pre-training, Better activation functions, Better weight initialization methods, Batch Normalization

SECTION C

CNN:

Convolutional Neural Networks, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet

RNN:

Learning Vectorial Representations of Words, Recurrent Neural Networks, Backpropagation Through Time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT, Gated Recurrent Units (GRUs), Long Short-Term Memory (LSTM) Cells, Solving the vanishing gradient problem with LSTMs

TEXT BOOKS

1. Ian Goodfellow and Yoshua Bengio and Aaron Courville. "Deep Learning. An MIT Press book". 2016.
2. Charu C. Aggarwal. "Neural Networks and Deep Learning: A Textbook". Springer. 2019.
3. Aston Zhang, Mu Li "Dive into Deep Learning", open-source link: https://arxiv.org/ftp/arxiv/papers/2106/2106.11342.pdf

REFERENCE BOOKS

1. Stephen Marsland, Machine Learning: An Algorithmic Perspective, CRC Press, 2014.
2. Zhi-Hua Zhou, Ensemble Methods: Foundations and Algorithms, CRC Press, 2012
3. Ethem Alpaydin, Introduction to Machine Learning, 4th edition, MIT Press 2020
4. Tom M. Mitchell, Machine Learning, McGraw-Hill Education (India) Private Limited, 2013.

ONLINE RESOURSES:

1. Deep Learning, Dr.Mitesh Khapra, IIT Madras, NPTEL Course https://www.youtube.com/watch?v=aPfkYu_qiF4&list=PLEAYkSg4uSQ1r-2XrJ_GBzzS6I-f8yfRU

IP-597 AUTOMATION, IOT AND ML LAB [0-0-3-2]

COURSE OUTCOMES

CO1. Ability to apply the basic knowledge of microcontroller programming.

CO2. Design and develop physical smart systems to control the process through sensors and transducers.

CO3. Expertise in using different supervised and un-supervised learning techniques.

CO4. Ability to develop an Industrial Internet of Things based process monitoring and control system using high end microcontrollers.

CO5. Ability to design and develop the PLC based automation for custom projects.

LIST OF EXPERIMENTS

MACHINE LEARNING

1. Write programs in Jupyter notebooks to do the following.
    i. Print first 10 whole numbers
    ii. Print first 10 natural numbers
    iii. Take an input from the user and print natural numbers upto that value
    iv. Print first 10 natural numbers except multiples of 4 in the range
    v. Take a number from the user and find its
        a) Factorial
        b) Sum of digits of the number entered
        c) Reverse of Digit
        d) Palindrome No
        e) Fibonacci Series upto that number

2. You are given with excel file named "Melbourne.csv". The file contains data of a large number of houses sold in Melbourne. Import data to pandas dataframe, do data cleaning, identify the price range, size range, range of number of rooms in the houses sold. Identify five most important parameters that effect the price, fit multiple regression model and determine the amount of variance explained.

3. From the various datasets available on sklearn, import load_iris dataset. It contains information on sepal and petal lengths and widths of a number of iris plants and their categories. Standardize this data, divide it into training and test datasets, fit various classification models on training datasets, check the prediction accuracies of models using confusion – matrix and identify the best performing model.

4. You are given with excel file named "Wholesale.csv". it contains data on eight important customer attributes. Use elbow method to determine optimal number of clusters. Fit K-means clustering model to the data, add a column and fill cluster value of each customer in it. Using the attributes information, give suitable name to each cluster.

INDUSTRIAL INTERNET OF THINGS

5. Simulate integration of various sensors and actuators with Arduino Uno on Tinkercad platform
6. Physical Integration of various sensors such as temperature, humidity, pressure, etc. with microcontrollers Arduino Uno for data acquisition.
7. Implementing cloud-based Data Storage and Retrieval through online platforms available such as AWS, Azure, or Google Cloud using Raspberry Pi.
8. Develop a trigger based process monitoring system to send email notifications for the process deviations.

INDUSTRIAL AUTOMATION

9. Programming practice of Programmable Logic Controllers (PLCs) using ladder logic and simulation software.
10. Programmable Logic Controllers (PLCs) programming using ladder logic diagrams and exposure to simulation software.
11. PID based control of a system.

IP-598 MANUFACTURING LAB-II [0-0-3-2]

COURSE OUTCOMES

At the end of the course, students will be able to

CO1. Operate the experimental setups and perform the experimentation on fibre laser texturing machine.

CO2. Operate the experimental setups and perform the machining experiments.

CO3. Select the process parameters of the machining processes, and analyze their influence on the properties of the fabricated materials.

CO4. Analyze the microstructures of the ferrous and non-ferrous metals.

CO5. Evaluate the microstructure and properties relationship of the fabricated materials obtained through forming operations.

LIST OF EXPERIMENTS:

1. Study the effect of laser parameters like processing speed, pulse frequency and raster step on surface roughness.
2. Study the effect of laser power, marking speed and pitch on hardness and roughness.
3. Study the effect of fibre laser parameters on the wettability of steel.
4. To write a manual part program to mill the given component by using CNC Vertical milling machine.
5. Evaluation of the effect of process parameters on cutting forces, surface finish and average cutting temperature in turning process.
6. Preparation of a single point cutting tool with a given tool geometry.
7. Study of microstructural changes after various manufacturing processes.
8. Severe Plastic Deformation: Effect of Severe Plastic Deformation on the Microstructure and properties (hardness).
9. Analysis of cutting forces in turning, milling, drilling: effect of speed, feed and depth of cut.
10. Analysis of temperature forces in turning, milling, drilling: effect of speed, feed and depth of cut.
11. Blanking and piercing operation and study of simple, compound and progressive press tool.
12. Hydraulic press: deep drawing and extrusion operation.

TEXT BOOKS

1. Manufacturing Science. Amitabha Ghosh and Mallick A. K, Affiliated East-West Press Pvt. Ltd. 2010.
2. Science and Engineering of Casting Solidification, Doru Michael Stefanescu, Springer, 2009
3. Welding Metallurgy, Sindo Kao, 2nd Edition, Wiley, 2002.
4. Fundamentals of Manufacturing Process, G. K. Lal and S. K. Choudhury, 2009, CRC Press.
5. Materials and Processes, in Manufacturing, Paul Degarmo E, Black J.T and Ronald A. Kosher, Eight Edition, Prentice –Hall of India, 1997.
6. Solidification and Casting, Brian Cantor, Keyna O'Reilly, Taylor and Francis, 2002.
7. Formability of Metallic Materials: Plastic Anisotropy, Formability Testing, Forming Limits, Dorel Banabic, Springer, 2010.

ONLINE RESOURCES

1. Laser: Fundamentals and Applications, NPTEL Course by Prof Manabendra Chandra, IIT Kanpur: https://nptel.ac.in/courses/104104085

IP-561 ADVANCED MATERIALS (INCLUDING COMPOSITES & PLASTICS) [3-0-0-3]

COURSE OUTCOMES

CO1. Understand the importance of advanced materials.
CO2. Apply the various manufacturing process with advanced materials.
CO3.Evaluate the mechanical behaviour and metallurgical aspects of advanced materials.
CO4. Analyze typical applications of advanced materials.

DETAILED SYLLABUS

High Temperature Materials: Introduction to high temperature materials, Factors influencing functional life of components at elevated temperatures, definition of creep curve, various stages of creep, metallurgical factors influencing various stages, effect of stress, temperature and strain rate

Design of transient creep, time hardening, strain hardening, expressions for rupture life for creep, ductile and brittle materials, Monk man - Grant relationship

Various types of fracture, brittle to ductile from low temperature to high temperature, cleavage, ductile fracture due to micro void coalescence - diffusion controlled void growth; fracture maps for different alloys and oxides

Ceramic Materials: Classification of ceramic materials, bonding and structure of ceramic materials, crystal structure and defects, variations within ceramics, defect structures, chronological developments, structure of silicates; polymorphic transformations, Advanced powder synthesis techniques. Advanced processing methods. Microstructural design and grain boundary engineering.

Composite materials: Classification of composites; comparison with metals and ceramics; Reinforcing and matrix materials; Fabrication processes; Phase selection criteria. Reinforcing mechanisms. Interfaces; bonding and failure criteria – micro mechanics approach

Polymers and Plastics: Physical Basis of Polymer Processing, Extrusion-Processes, Injection Moulding-Principles, Fibre Reinforced Plastics-Materials-Lay-up processes, Rheological parameters stress, strain and rate of deformation

TEXT BOOKS

1. Hertzberg R W, "Deformation and Fracture Mechanics of Engineering Materials", 4th Edition, John Wiley, 1996
2. Courtney T H, "Mechanical Behaviour of Materials", McGraw Hill, 1990
3. Mallick, P K, "Fiber Reinforced Composites Materials", Manufacturing and Design. Marcel Dekker Inc, New York, 1993
4. Kingery W D, Bowen, H K, Uhlhmen D R, "Introduction to Ceramics", 2nd Edition, John Wiley, 1976
5. Norton F H, "Elements of Ceramics" 2nd Edition, Addison Wesley, 1974
6. Van Vlack L H, "Physical Ceramics for Engineers", Addison Wesley, 1964
7. Gandhi, M V and Thompson, B S, "Smart materials and Structures", Chapman and Hall, 1992.

REFERENCE BOOKS

1. Raj R, "Flow and Fracture at Elevated Temperatures", American Society for Metals, 1985
2. Billmeyer F, "Textbook of Polymer Science", Wiley Interscience, 1994
3. Anthoney Kelly, "Concise Encyclopedia of Composite Materials", Pergamon, 1994

4. Richerson D. W., "Modern Ceramic Engineering - Properties Processing and Use in Design", 3rd Edition, CRC Press, 2006
5. Chiang Y M, Birnie D. P., Kingery W D, "Physical Ceramics: Principles for Ceramic Science and Engineering", John Wiley, 1997

ONLINE RESOURSES

1. Advanced Materials And Metallurgy, NPTEL course, Professor B. S. Murty, IIT Kharagpur: https://nptel.ac.in/courses/113105057/
2. Advanced Materials And Metallurgy, NPTEL course, Professor Jayanta Das, IIT Kharagpur: https://nptel.ac.in/courses/113105081/

IP-562 COMPUTER INTEGRATED MANUFACTURING [3-0-0-3]

COURSE OUTCOMES

At the end of the course, student will be able to:

CO1. Gain a comprehensive understanding of the principles, concepts, and components of Computer Integrated Manufacturing systems

CO2. Create and modify 3D models and generate machining instructions

CO3. Understand about industrial robotics and automation systems

CO4. Develop problem-solving and troubleshooting skills to identify and address issues related to CIM systems

CO5. Create awareness of industry trends and emerging technologies in the field of CIM

DETAILED SYLLABUS:

- Introduction to computer integrated manufacturing, overview of CIM and its significance in modern manufacturing, role of computers, automation, and information systems in CIM.
- Computer-Aided Design (CAD): Introduction to CAD software and its capabilities, 2D and 3D modeling techniques, CAD file formats, data exchange
- Computer-Aided Manufacturing (CAM): CAM systems and their integration with CAD, Toolpath generation and optimization, Post-processing and machine simulation.
- Computer Numerical Control (CNC) Machining: Principles of CNC machining and programming, CNC machine components and their functions, G-code programming and CNC machine operation.
- Robotics and Automation: Introduction to industrial robots and their applications, Robot programming and control, Integration of robots with manufacturing processes.
- Manufacturing Resource Planning (MRP II): Overview of MRP II systems and their functionalities, Material planning, inventory management, and procurement in MRP II, Integration of MRP II with other CIM components.
- Enterprise Resource Planning (ERP): Introduction to ERP systems and their benefits, Integration of manufacturing, finance, and other business functions in ERP, ERP implementation and challenges.
- Manufacturing Data Management: Data modeling and database systems in CIM, Product data management (PDM) and product lifecycle management (PLM), Data security, integrity, and access control in CIM.
- Integration of Manufacturing Systems: Interfacing and communication standards in CIM, Integration of CAD, CAM, CNC, MES, and ERP systems
- Quality Control and Inspection in CIM: Statistical process control (SPC) techniques., Inspection technologies and equipment, Automated inspection and quality assurance in CIM.

- Emerging Technologies in CIM: Internet of Things (IoT) and its role in manufacturing, Additive manufacturing and its integration with CIM, Cloud computing, big data analytics, and artificial intelligence in CIM.

TEXT BOOKS

1. "Computer Integrated Manufacturing" by James A. Rehg and Henry W. Kraebber
2. "Computer Integrated Manufacturing: From Fundamentals to Implementation" by Timothy L. Baines, Paul A. Ladley, and David J. Harrison
3. "Computer Integrated Manufacturing Systems" by N. Viswanadham and Y. Narahari
4. "Introduction to Computer-Integrated Manufacturing" by James A. Rehg and Henry W. Kraebber
5. "Principles of Computer-Integrated Manufacturing" by S. Kant Vajpayee
6. "Computer Integrated Manufacturing: From Concepts to Realization" by Alojz Pecar and Milan Milanovic:

IP-563 DESIGN FOR MANUFACTURING AND ASSEMBLY [3-0-0-3]

COURSE OUTCOMES

Students will be able to:

CO1. Apply Design for Manufacturing and Assembly (DFMA) principles to optimize product designs for cost, quality, and ease of manufacturing and assembly.

CO2. Analyze a product design and identify opportunities for improving manufacturability and assembly.

CO3. Utilize DFMA software tools for design analysis and optimization.

CO4. Understand the different manufacturing and assembly processes and how to design for each process.

CO5. Work collaboratively in a team to apply DFMA principles to a product design project.

DETAILED SYLLABUS

Introduction: What is DFMA and why is it important? Overview of the DFMA process, Case studies of successful DFMA implementations

Product Design Principles for DFMA: Design for simplicity, Design for modularity,Design for standardization, Design for ease of assembly

Manufacturing Processes and DFMA: Overview of manufacturing processes, Design considerations for different manufacturing processes (e.g., casting, molding, machining, additive manufacturing), Design for manufacturability guidelines

Assembly Processes and DFMA: Overview of assembly processes, Design considerations for different assembly processes (e.g., manual assembly, automated assembly), Design for assembly guidelines

Cost Analysis for DFMA: Overview of cost analysis for DFMA, Identifying cost drivers in manufacturing and assembly, Cost reduction strategies

Design Optimization and DFMA: DFMA software tools, Design optimization techniques for DFMA, Case studies of design optimization for DFMA

Advanced Topics in DFMA: Lean manufacturing and DFMA, Design for sustainability, Design for quality

TEXT BOOKS

1. "Design for Manufacturability & Concurrent Engineering: How to Design for Low-Cost, Design in High Quality, Design for Lean Manufacture, and Design Quickly for Fast Production" by David M. Anderson (2014)
2. "Design for Manufacturability Handbook" by James G. Bralla (2017)
3. "DFMA: Simplified Steps for Design for Manufacture and Assembly" by Geoffrey Boothroyd, Peter Dewhurst, and Winston Knight (2010)
4. "Lean Product and Process Development" by Allen C. Ward and Durward K. Sobek II (2014)
5. "Design for Six Sigma for Green Belts and Champions: Applications for Service Operations—Foundations, Tools, DMADV, Cases, and Certification" by Howard S. Gitlow, David M. Levine, and Edward W. Nilsson (2006).
6. DFMA: Simplified Steps for Design for Manufacture and Assembly" by Geoffrey Boothroyd, Peter Dewhurst, and Winston Knight - Latest edition: 3rd Edition (2019)

7. "Design for Manufacturability & Concurrent Engineering: How to Design for Low-Cost, Design in High Quality, Design for Lean Manufacture, and Design Quickly for Fast Production" by David M. Anderson - Latest edition: 2nd Edition (2014)
8. "Product Design for Manufacture and Assembly" by G. Boothroyd and P. Dewhurst - Latest edition: 3rd Edition (2010)
9. "DFMA Reducing Time to Market and Improving Quality Through Concurrent Engineering" by Geoff Boothroyd and Peter Dewhurst - Latest edition: 1st Edition (2002)

REFERENCE BOOKS

1. "Design for Manufacturability Handbook" by James G. Bralla - Latest edition: 2nd Edition (2017)
2. "DFMA Principles for Power Electronics" by Sam Ben-Yaakov and J. B. Klaassens - Latest edition: 1st Edition (2019)
3. "DFMA by Design for Assembly and Manufacturing" by David M. Anderson - Latest edition: 1st Edition (2010)
4. "DFMA: A Tool for Enhancing Product Development" by Fred W. Rosenberger - Latest edition: 1st Edition (2002)

ONLINE RESOURCES

1. Design for Manufacture and Assembly:
   Link: https://nptel.ac.in/courses/112/105/112105120/
   Professors: Prof. Amaresh Chakrabarti and Prof. Indranil Bhattacharya, Indian Institute of Science Bangalore.

   Product Design and Development:
   Link: https://nptel.ac.in/courses/122/106/122106126/
   Professors: Prof. Nachiketa Tiwari and Prof. J. Ramkumar, Indian Institute of Technology Delhi.

   Quality and Reliability in Engineering Design:
   Link: https://nptel.ac.in/courses/122/107/122107133/
   Professors: Prof. J. Ramkumar and Prof. I. M. Mishra, Indian Institute of Technology Delhi.

   1. DFMA Principles for Engineers: Link: https://www.edx.org/course/dfma-principles-for-engineers
   2. Product Design for the Environment: Link: https://www.edx.org/course/product-design-for-the-environment
   4. Product Design and Development: Link: https://www.coursera.org/learn/product-design

IP-564 FATIGUE IN MANUFACTURING [3- 0 -0 -3]

COURSE OUTCOMES

At the end of the course, students will be able to:
CO1. Understand basic fundamentals of fatigue
CO2. Apply the concepts with fracture mechanics
CO3. Analyze and develop new mathematical models.
CO4. Learn the effect of environmental factors on fatigue
CO5. Evaluate the failure in weldments due to fatigue

DETAILED SYLLABUS

Stress-Life (S-N Approach): Fatigue loading, fatigue phenomenon, test machines and specimens, stress life (S-N) curves, mean stress effects on S-N Behavior, S-N Curve representation and approximations, modifying factors, design S-N curves, fatigue strength testing, Notch effect, Mean stress effect:

Strain Life Approach: Monotonic tension test and stress and strain behaviour, strain controlled test methods, Analysis of monotonic and cyclic stress-strain behaviour: mean stress correction methods, estimation of cyclic and fatigue properties, notch analysis,

Multiaxial Stresses: States of stress and strain and proportional versus non proportional loading, yielding and plasticity in multiaxial fatigue, stress based criteria, strain based, energy based and critical plane approaches

Fundamentals of LEFM and Fatigue Crack Growth: LEFM concepts, crack tip plastic zone, fatigue crack growth law, Mean stress effects, cyclic plastic zone size, crack closure, small fatigue cracks, plasticity extension of LEFM and EPFM, Walker Equation, Forman Equation, life estimation

Environmental Effects: Corrosion fatigue, SCC, fatigue crack growth behaviour, fretting and mechanism, fatigue, low temperature fatigue, high temperature fatigue, neutron irradiation

Fatigue of Weldments: Weldment nomenclature and discontinuities, constant amplitude fatigue behaviour of weldments, stress life, strain life, crack growth behaviour, spot weld, improving weldment fatigue resistance, weldment fatigue life estimation

TEXT BOOKS

1. Metal Fatigue in Engineering, R.I. Stephens, A. Fatemi, R.R. Stephens and H.O. Fuchs, Wiley India Edition, 1980.
2. Fatigue Testing and Analysis – Theory and Practice, Y. Lee, J. Pan, R. Hathaway and M. Barkey, Elsevier Publication, 2011.
3. Elementary Engineering Fracture Mechanics, D. Broek, Kluwer Acaedemic Publication, 2012.
4. J.E. Shigley and C.R. Mischke, Mechanical Engineering Design, Mc Graw Hill book, 2002.

ONLINE RESOURSES

1. Metal Fatigue, NPTEL course, Prof. S.R. Satish Kumar and Prof. A.R. Santha Kumar: https://nptel.ac.in/courses/105106112/1_introduction/7_Fatigue.pdf

IP-565 FINITE ELEMENT METHOD [3-0-0-3]

COURSE OUTCOMES

At the end of the course, students will be able to:
CO1. Understanding of finite element method for 1-D problems
CO2. Apply numerical methods to solve mechanics of solids problems
CO3. Analyze two-dimensional problems using triangle and quadrilateral elements.
CO4. Evaluate axisymmetric and heat transfer problems.

DETAILED SYLLABUS

Basic concepts: Variational and Residual methods-Introduction - Different approaches in Finite Element Method - Direct Stiffness approach, simple examples Variational approach, Elements of variational calculus – Euler's-Lagrange equation, Rayliegh Ritz method , Weighted Residual methods, Point Collation method, Sub domain Collation method, Galerkins method - Steps involved in FEM.

Elements and Interpolation Functions: Elements and coordinate system -Interpolation Polynomials - Linear elements Shape function - Analysis of simply supported beam - Element and Global matrices - Two dimensional elements, triangular and rectangular elements - Local and Natural Co-ordinate systems.

Finite Element Solution of Field Problems: Field problems – Finite element formation of field problems - Classification of partial differential equations – Quasi-harmonic equation - Steady state problems - Eigen value problems - Propagation problems - Examples, Torsional problem - Fluid flow and Heat transfer problems - Acoustic vibrations – Application in manufacturing problems – metal cutting and metal forming.

Finite Element Solution of Structural Problems: Solid mechanic problems – Finite element formulation of solid mechanic problems - Axial force member - element matrices for axial force members - Truss element analysis of pinned truss - Two dimensional elasticity problems.

Higher Order Elements and Numerical Methods: Numerical method and computer implementation –Numerical method in FEM and Computer implementation. Evaluation of shape functions - One dimensional & triangular elements, Quadrilateral elements, Iso-parametric elements - Numerical Integration, Gauss Legendre quadrature - Solution of finite element equations - Cholesky decomposition - Computer implementation- Use of FEM software.

TEXT BOOKS

1. Larry J Segerlind, "Applied Finite Element Analysis‖", John Wiley, 1984
2. Bathe, K J, "Finite Element Procedures‖", Prentice Hall, 1994.
3. Huebner, K H and Thornton, E.A., "The Finite Element Method for Engineers", John Wiley, 1982.
4. Reddy,J N., ―Introduction to Finite Element Method‖, McGraw Hill, 1993
5. Zienkiewich . O.C., and Taylor. R L "The Finite Element Method‖", McGraw-Hill,1991.
6. Rao S S, "Finite element method", 1995.

ONLINE RESOURCES

1. Finite Element Method, NPTEL course, Professor R. Krishna kumar, IIT Madras: https://archive.nptel.ac.in/courses/112/106/112106135/

IP-566 INSPECTION AND TESTING IN MANUFACTURING [3-0-0-3]

COURSE OUTCOMES

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

CO1: Learn and understand the basic concepts of inspection and testing in manufacturing.

CO2: Apply the different statistical quality control techniques to solve problems of inspection.

CO3: Apply the different testing standards in manufacturing through case studies.

CO4: Evaluate the mechanical and metallurgical behaviour of materials through destructive and non-destructive testing techniques using standardized methodology.

DETAILED SYLLABUS

Introduction to inspection: Need, importance, basic metrology methods of inspection, Statistical quality control techniques applied for inspection, Statistical methods and management aspects for quality control and improvement, Applications of statistical quality control, basic concept about application of control charts and acceptance sampling for testing and inspection of samples. Applications for variables control charts.

Testing standards: Definition of standards and their importance in manufacturing, Types of standards: National, International, Industrial, Product and Process Standards, Implementation of Standards in Manufacturing, Case studies related to inspection and testing standards of materials: e.g. tension, compression, hardness, microscopy, fatigue, impact etc., Case studies related to the implementation of standards in fabrication.

Destructive testings: Classification and description of destructive testing techniques like Tensile test, Bend test, Impact test, Hardness test, Fatigue test; Testing of welding consumables-All weld test, Determination of diffusible hydrogen, Deposition efficiency, Coating moisture determination etc.

Non-Destructive testings: Scope and significance of non-destructive testing. Principles, equipment, specifications and limitations of liquid penetrant, Magnetic particle, Eddy current, Ultrasonic and Acoustic emissions, and Radiography (X-Ray and Gamma Ray), Material characterization techniques such as electron microscopy, diffraction methods etc.

TEXT BOOKS

1. Montgomery, Douglas C, "Statistical Quality Control, 7th Edition", Wiley, 2012.
2. Jayamangal Prasad, C. G. Krishnadas Nair, "Nondestructive testing test and evaluation of materials", Tata McGraw-Hill, 2008.
3. Baldev Raj, T. Jayakumar, M. Thavasimuthu, "Practical Non-destructive Testing", Narosa Publishing House, 2002.
4. Bhargava A. K., C. P. Sharma, "Mechanical Behaviour and Testing of Materials", PHI Learning Pvt. Ltd., 2011.
5. Gupta, I.C., "Text Book of Engineering Metrology", Dhanpat Rai Publishing Co.
6. "Nondestructive Evaluation and Quality Control", ASM Handbook, Vol. 17 of 9th Edition Metals Handbook.
7. "Welding Inspection", 3rd Edition, American Welding Society.
8. Winchell William, "Inspection and Measurement in Manufacturing", Society of manufacturing Engineers.

ONLINE RESOURCES

Inspection and quality control in manufacturing, NPTEL course, Professor Kaushik Pal, IIT Roorkee: https://archive.nptel.ac.in/courses/112/107/112107259/.

IP-567 LASERS IN MANUFCTURING [3-0-0-3]

COURSE OUTCOMES

At the end of the course the students are expected to
CO1. Understand the basics of laser physics, laser optics, and laser-materials interaction;
CO2. Distinguish the types of lasers and its applications;
CO3. Employ laser for surface engineering, welding, cutting, and drilling;
CO4. Analyze the micro machining processes by lasers.

DETAILED SYLLABUS

Fundamentals of laser - lasing action- properties - spectrum and wavelength –wave length chart-types of laser- modes of operation-continuous mode-pulsed mode-laser components - interaction of laser radiation with materials-long pulse and short pulse interaction.
Laser surface treatment - forms of laser surface treatment-laser transformation hardening - advantages - laser surface melting - laser alloying - laser cladding-co-axial powder feeding-lateral powder feeding-laser texturing-case examples.
Laser welding - process arrangement - mechanisms - applications –modes of welding-conduction limited welding-key hole welding-heat flow theory - one dimensional heat flow - model for stationary and moving point source - simulation of laser welding.
Laser cutting - process characteristics-theoretical models of cutting - practical performance-applications - process variations - drilling –single pulse drilling-percussion drilling- trepanning-applications.
Fiber Laser and UV Laser based marking - micromachining solutions - laser shock loading - basics - applications - laser safety - danger - safety limits - eye and skin - class four safety arrangements - electric hazards - fume hazards.

TEXT BOOKS

1. K Thyagarajan, Ajoy K Ghatak, "Lasers, Theory and Applications", Plenum Press, 1981.
2. J F Reddy, "Industrial Applications of Lasers", Academic Press, New York, 1978.
3. S S Charschan, "Lasers in Industry", Wiley & Sons Inc., 1974.

REFRENCE BOOKS

1. William M Steen, "Laser Material Processing", Springer Verlag, 2003.
2. M Young, "Optics and Lasers", Springer, 1993.
3. Michael Bass, "Laser Materials Processing", Elsevier Science, 1983.

ONLINE RESOURSE

1. Laser: Fundamentals and Applications, NPTEL Course by Prof Manabendra Chandra, IIT Kanpur: https://nptel.ac.in/courses/104104085
2. Laser Based Manufacturing, NPTEL Course by Prof S N Joshi, IIT Guwahati: https://archive.nptel.ac.in/courses/112/103/112103312/

IP-568 MACHINE TOOL DESIGN [3-0-0-3]

COURSE OUTCOMES

Students will be able to: Understand and design mechanical components of machine tools. Apply modern manufacturing technologies and design electrical and control systems. Analyze and design the kinematics of machine tools. Understand the mechanics of machine tools, including stress and strain analysis.

DETAILED SYLLABUS

Introduction to Machine Tool Design: Overview of machine tools, types of machine tools, classification of machine tools, design requirements, and factors affecting machine tool design.

Mechanics of Machine Tools: Static and dynamic analysis of machine tools, stress analysis, strain analysis, and fatigue analysis.

Kinematics of Machine Tools: Principles of motion, velocity and acceleration analysis, design of mechanisms, cam and follower systems, and gear trains.

Design of Machine Tool Structures: Structural elements of machine tools, design of beds, columns, and machine frames, and optimization of machine tool structures.

Design of Spindles, Bearings, and Lubrication Systems: Design of spindle bearings, types of bearings, lubrication systems, and heat dissipation in machine tools.

Design of Cutting Tool Systems: Design of cutting tools, tool holders, tool post, and tool layout.

Design of Workholding Devices: Design of workholding devices, types of workholding devices, and clamping systems.

Electrical and Control Systems for Machine Tools: Electrical and control systems for machine tools, sensors, feedback systems, and CNC machines.

Design of Jigs and Fixtures: Design of jigs and fixtures, types of jigs and fixtures, and design considerations for jigs and fixtures.

Modern Trends in Machine Tool Design: Recent advances in machine tool design, additive manufacturing, and Industry 4.0 technologies.

Text Books

"Machine Tool Design and Numerical Control" by N.K. Mehta - Latest edition: 1st Edition (2009)

"Design of Machine Elements" by V.B. Bhandari - Latest edition: 4th Edition (2019)

"Machine Tool Practices" by R.K. Jain and S.C. Gupta - Latest edition: 9th Edition (2021)

"Principles of Machine Tools" by A.B. Chattopadhyay - Latest edition: 2nd Edition (2019)

"Design of Jigs, Fixtures and Press Tools" by K. Venkataraman - Latest edition: 2nd Edition (2019)

"Theory of Machines and Mechanisms" by J.S. Rao and R.V. Dukkipati - Latest edition: 5th Edition (2019)

Reference Books

"Design of Machine Tools" by K.C. John - Latest edition: 3rd Edition (2021)

"Machine Tool Design Handbook" by Central Machine Tool Institute - Latest edition: 2nd Edition (2018)

"Metal Cutting Principles" by M.C. Shaw - Latest edition: 3rd Edition (2020)

"Advanced Machining Processes" by V.K. Jain - Latest edition: 1st Edition (2018)

Online Resources

Design of Machine Elements - I by Prof. M. S. Sivakumar - https://nptel.ac.in/courses/112/106/112106083/

Machine Design - II by Prof. G. Chakraborty - https://nptel.ac.in/courses/112/103/112103056/

Advanced Machining Processes by Prof. Vijayan Krishnaraj - https://nptel.ac.in/courses/112/108/112108131/

Advanced Manufacturing Processes by Prof. S. Paul and Prof. A. Chattopadhyay - https://nptel.ac.in/courses/112/106/112106135/

Precision Engineering by Prof. K. Gopinath and Prof. I. S. Jawahir - https://nptel.ac.in/courses/112/106/112106104/

Manufacturing Processes II by Prof. A. K. Chattopadhyay - https://nptel.ac.in/courses/112/102/112102012/

Fundamentals of Machining and Machine Tools by Dr. Vikrant Sharma on edX - https://www.edx.org/course/fundamentals-of-machining-and-machine-tools

Mechanical Design: Machine Components and Assemblies by Prof. G. W. Burns on Coursera - https://www.coursera.org/learn/mechanical-design-machine-components

Machine Design Part I by Prof. David M. Diefenderfer on Coursera - https://www.coursera.org/learn/machine-design-1

IP-569 MACHINING SCIENCE [3-0-0-3]

COURSE OUTCOMES

After completing the course students will be able to:
CO1: To understand metal cutting, chip formation, tool geometry.
CO2: To analyze cutting forces, temperature, power and specific energy along the shear and rake planes, and temperature in machining.
CO3: To evaluate the mechanism of oblique cutting, practical machining operations, and grinding processes
CO4: To select tool material considering tool wear, tool life and economics of machining

DETAILED SYLLABUS

Introduction:
Machining; Plastic Deformation, Tensile Test, Stress and Strain; Mechanism of Plastic Deformation: Slips, defects, plastic deformation on atomic scale.

Machining Process:
Types of machining processes; Chip formation; Orthogonal and Oblique Cutting; Types of Chips; Built-up edge formation.

Tool Geometry:
Reference planes; Tool specification: American System (ASA), continental or Orthogonal System (ORS), International or Normal Rake system (NRS); Tool angle relationships in ORS, ASA and NRS; Selection of Tool Angles; Multiple-point cutting tools: twist drill, helical milling cutter.

Mechanics of Metal Cutting:
Merchant's Circle Diagram; Co-efficient of Friction: Determination of stress, strain and strain rate; Measurement of shear angle; Thin Zone model: Lee and Shaffer's Relationship; Thick Zone model: Okushima and Hitomi Analysis.

Friction in Metal Cutting:
Nature of sliding friction; Friction in Metal Cutting: Sticking and Sliding Zones, Analysis of Stress Distribution on the tool face: Zorev's model; Determination of mean angle of friction.

Mechanism of Oblique cutting:
Rake angles in oblique cutting: Analytical determination of Normal Rake angle, velocity rake angle and effective rake angle; their relationship; shear angles in oblique cutting; velocity relationship; Force relationships in oblique cutting.

Practical Machining Operations:
Turning, shaping and planning, Slab milling, Drilling: Machining Parameters, force magnitudes, power consumption, material removal rate, time per pass.

Measurement of cutting Forces:
Basic methods of measurement: Axially Loaded members, Cantilever Beam, Rings and Octagon, dynamometer requirements; machine tool dynamometers.

Tool Material, Tool Wear and Tool Life:
Types of tool wear; Mechanisms of wear: Abrasion, Adhesion and Diffusion. Progressive tool wear: flank and crater wear. Tool Life: variables affecting tool life - cutting conditions, tool

geometry, Types of tool materials, fabrication of cutting inserts, coatings, work material and cutting fluid; Machinability and their criteria.

Economic of Machining:

Minimum Production Cost Criterion; Maximum Production Rate Criterion, and Maximum Profit Rate Criterion. Restrictions on cutting conditions: maximum power restriction, speed restriction, force and vibration restriction, surface finish restriction.

Thermal Aspects of Machining:

Distinct regions of heat generation; Equations of Heat Flow: heat Flow due to conduction, heat flow due to transportation, heat absorbed and heat generated; Average Shear Plane temperature; Average Chip-tool interface Temperature; Experimental determination of cutting temperatures.

Abrasive Machining Process:

Introduction: Types of abrasive machining processes; Grinding; types and characteristics; characteristics and specification of grinding wheels; Mechanics of Grinding Process; Determination of chip length in Grinding; Size effect; Wheel wear; Thermal Analysis; Honing and Lapping.

TEXT BOOKS

1. Armarego, E. J. A., and Robert Hallowes Brown. "The machining of metals." PRENTICE-HALL INC, ENGLEWOOD CLIFFS, N. J., 1969.
2. Boothroyd, Geoffrey, "Fundamentals of metal machining and machine tools". Vol. 28. CRC Press, 1988.
3. Ghosh, Amitabha, and Asok Kumar Mallik. "Manufacturing science." Ellis Horwood, 1986. (1986).
4. Lal, G. K. "Introduction to machining science", New Age International, 1996.

REFERENCE BOOKS

1. Shaw, Milton Clayton, and J. O. Cookson, "Metal cutting principles", Vol. 2, no. 3. New York: Oxford university press, 2005.
2. Bhattacharyya Amitabha, "Metal Cutting: Theory and Practice", New Central Book Agency, 1984

ONLINE RESOURSES

1. Mechanics of Machining, NPTEL Course, Prof. Uday S Dixit, IIT Guwahati, https://archive.nptel.ac.in/courses/112/103/112103248
2. Manufacturing Processes II, NPTEL Course, Prof. A.K. Chattopadhyay, Prof. A.B. Chattopadhyay Prof. S. Paul, IIT Kharagpur, https://archive.nptel.ac.in/courses/112/105/112105126

IP-570 MATHEMATICAL METHODS IN ENGINEERING [3-0-0-3]

COURSE OUTCOMES

1. Understand the mathematical techniques used in engineering analysis.
2. Apply complex variables to solve engineering problems.
3. Understand the properties of Fourier series and transforms and their applications.
4. Ability to Solve partial differential equations using analytical methods.
5. Ability to analyse complex engineering problems using numerical methods.

DETAILED SYLLABUS

Unit 1: Complex Variables

Complex numbers and operations, Functions of a complex variable, Analytic functions and Cauchy-Riemann equations, Complex integration, Cauchy's integral theorem and integral formula (without proof), Taylor's and Laurent' series

Unit 2: Fourier Series and Transforms

Laplace transform, Fourier series and their properties, Inverse Fourier transforms, Applications of Fourier transforms to engineering problems

Unit 3: Partial Differential Equations

Classification of partial differential equations, Solution of first-order partial differential equations, Solution of second-order partial differential equations using separation of variables, Laplace equation, heat equation, and wave equation

Unit 4: Numerical Methods

Taylor series and finite differences, Numerical differentiation and integration, Solution of ordinary differential equations using numerical methods, Solution of partial differential equations using numerical methods,

Unit 5: Applications of Mathematical Methods in Engineering

Control systems, Signal processing, Fluid mechanics, Electromagnetics

Reference Books:

Kreyszig, E. (2011). Advanced Engineering Mathematics (10th ed.). Wiley.

IP-571 MECHANICS OF COMPOSITE MATERIALS [3-0-0-3]

COURSE OUTCOMES

CO1. Understand the basics of composite materials, their manufacturing process

CO2. Apply the mechanical properties of composite materials

CO3. Evaluate the stiffness matrix and 2D relationships and matrix in composite materials

CO4. Analyze the macro mechanical properties of laminates

DETAILED SYLLABUS

Classification, Types, characteristics and selection of composites, prepegs, sandwich construction.

Micro and Macro mechanics of a lamina: four elastic moduli – Rule of mixture, ultimate strengths of unidirection lamina - Hooke's law - number of elastic constants - Two – dimensional relationship of compliance & stiffness matrix.

Macro Mechanical analysis of laminate - Kirchoff hypothesis – CLT, A,B,& D matrices - Engineering constants - Special cases of laminates, Failure criterion.

Manufacturing processes and Quality assurance of composites.

Metal matrix composites, Application developments - future potential of composites.

TEXT BOOKS

1. Mein Schwartz, "Composite Materials Hand Book", McGraw Hill, 1984.
2. Autar K Kaw, "Mechanics of Composite Materials", CRC Press, 1994.
3. Rober M Joness, "Mechanics of Composite Materials", McGraw HIll,1982

ONLINE RESOURSES

1. Mechanics Of Composite Materials, NPTEL course, Professor Nachiketa Tiwari, IIT Kanpur: https://nptel.ac.in/courses/112104229/2

IP-572 NON-CONVENTIONAL MACHINING TECHNIQUES [3-0-0-3]

COURSE OUTCOMES

After completing the course students will be able to:
CO1: To understand the need and classification of different advanced machining methods.
CO2: To apply the abrasive based machining technique considering quality of product required and material removal rate.
CO3: To analyze various thermal energy source for advanced machining of metals/ non-metals, ceramics and composites.
CO4: To evaluate the chemical and electro-chemical means for the material removal in advanced materials.
CO5: To create or develop hybrid non-traditional machining techniques from the available conventional and non-conventional methods

DETAILED SYLLABUS

Introduction: Evolution, Types, need, and classification of non-conventional machining processes (NCMPs).

Abrasive jet machining (AJM), Ultrasonic machining (USM), Water jet cutting (WJC) and Abrasive water jet machining (AWJM), Magnetic abrasive finishing (MAF), Abrasive flow finishing (AFF), Magnetorheological finishing (MRF), Magnetorheological abrasive flow finishing (MRAFF). Process principle and elements; Tool design; Mechanism of material removal, Process parameters; Shape and material applications; Operational characteristics; Limitations.

Electric discharge machining (EDM): Principle, applications, process parameters, and modelling, Electric Discharge Grinding (EDG), Electric Discharge Diamond Grinding (EDDG), and Wire Electric Discharge Machining (W-EDM), Laser beam machining (LBM), Plasma arc machining (PAM), Electron Beam Machining (EBM). Process principle and elements; Tool design; Mechanism of material removal, Process parameters; Shape and material applications; Operational characteristics; Limitations.

Electro chemical machining (ECM): Principle, applications, and process parameters and modelling, Electrochemical Grinding (ECG), Electrostream Drilling (ESD), Shaped Tube Electrolytic Machining (STEM), Chemical machining (ChM). Process principle and elements; Tool design; Mechanism of material removal, Process parameters; Shape and material applications; Operational characteristics; Limitations.

Derived/Hybrid non-conventional machining processes

TEXT BOOKS

1. Jain, V K, "Advanced Machining Processes", Allied Publishers, 2011.
2. Benedict, G F, "Nontraditional Manufacturing Processes", Marcel Dekker, 2017.
3. McGeough, J A , "Advance Method of Machining", Chapman and Hall, 1988.
4. Mishra, P K, "Nonconventional Machining", Narosa Publishing House, 2007.
5. Gupta, K, Jain, N K, Laubscher, R F "Hybrid Machining Processes - Perspectives on Machining and Finishing", Springer Publications, 2015.
6. Xichun L, Yi Q., "Hybrid Machining - Theory, Methods, and Case Studies", 1st Edition, Elseveir Publications, 2018.

REFERENCE BOOKS

1. Pandey, P.C., and Shan, H.S., "Modern Machining Processes", Tata McGraw-Hill, 1980.
2. Ghosh, A., and Mallik, A.K., "Manufacturing Science", Affiliated East-West Press, 1999.

ONLINE RESOURSES

1. Advanced Machining Processes, NPTEL course, Dr. Manas Das, Department of Mechanical Engineering, IIT Guwahati: https://archive.nptel.ac.in/courses/112/103/112103202/

IP-573 SMART MATERIALS AND MEMS [3-0-0-3]

COURSE OUTCOMES

After studying this course, the students shall be able

CO1	To understand the fundamental principles and characteristics of smart materials and their applications in various fields.
CO2	To explain the principles and working mechanisms of different types of smart materials, including piezoelectric materials, shape memory alloys, electroactive polymers, and magnetostrictive materials.
CO3	To analyze the role and significance of smart materials in the development of innovative devices, systems, and technologies.
CO4	To develop critical thinking and problem-solving skills to address real-world challenges related to smart materials and MEMS.

Smart materials and MEMS: Introduction, historical background and development, Importance and significance of smart materials and MEMS in various fields.

Smart Materials:

Piezoelectric Materials, Applications of piezoelectric materials in sensors, actuators, and energy harvesting.

Shape Memory Alloys (SMAs): SMAs and their unique characteristics, transformation behavior and thermomechanical properties of SMAs, applications of SMAs in robotics, aerospace, biomedical devices, etc.

Electroactive Polymers (EAPs): EAPs and their electro-mechanical coupling, types of EAPs and their properties, applications of EAPs in artificial muscles, sensors, and other fields.

Magnetostrictive Materials: Introduction, properties, applications of magnetostrictive materials in sensing, actuation, and energy harvesting.

Electro-rheological and magneto rheological fluids: Mechanism, properties and characteristics

MEMS Technology:

Fundamentals of MEMS: Introduction to MEMS technology and its advantages, Scaling laws and miniaturization aspects in MEMS devices, Overview of fabrication techniques for MEMS devices.

MEMS Sensors: Principles and working of different MEMS sensors (accelerometers, gyroscopes, pressure sensors, etc.), design considerations and fabrication techniques for MEMS sensors, applications of MEMS sensors in automotive, consumer electronics, healthcare, etc.

MEMS Actuators: Introduction to various MEMS actuation mechanisms (electrostatic, piezoelectric, thermal, etc.), design, fabrication, and characterization of MEMS actuators, Applications of MEMS actuators in micro-robotics, optical systems, etc.

Emerging Smart Materials and Future Trends: Self-healing materials, nanomaterials, etc, latest advancements and research trends in smart materials and MEMS.

TEXT BOOKS

1. "Smart Materials and Structures: Basic Concepts and Applications" by N. M. Ravindra and S. V. Sreenivasulu
2. Introduction to Smart Materials" by S. M. Sapuan
3. "Smart Materials for Engineers" by N. A. A. Osman, M. R. B. Osman, and M. I. Ismail
4. "MEMS and Microsystems: Design, Manufacture, and Nanoscale Engineering" by Tai-Ran Hsu
5. "Microelectromechanical Systems (MEMS): Design and Fabrication" by Mohamed Gad-el-Hak
6. "Smart Materials-Based Actuators at the Micro/Nano-Scale: Characterization, Control, and Applications" by Qingsong Xu and Yi Zhang

ONLINE RESOURSES

https://nptel.ac.in/courses/112104173

Smart Material, Adaptive Structures and Intelligent Mechanical Systems - IITK, IIT Kanpur by Prof. Nachiketa Tiwari, Prof. Bishakh Bhattacharya

IP-574 THEORY OF PLASTICITY [3-0-0-3]

COURSE OUTCOMES

After completing the course students will be able:
CO1. To understand the relationship between stress and strain during the plastic deformation
CO2. To apply the mathematical relations to model the deformation and rate of deformation CO3. To analyze the constitutive relationship for elastic plastic material.
CO4. To evaluate the role of plastic anisotropy in the plastic deformation Enable students to
CO5. To co-relate and apply the concept of Plasticity in practical application of industry like metal forming and manufacturing

DETAILED SYLLABUS

Introduction: Concept of plastic deformation using simple ideas and familiar examples, strain hardening postulates, plastic flow rule, Physical overview of crystal plasticity, plasticity of granular media, plasticity in rubber-like materials, etc.

Stress and Strain: State of stress at a point, virtual work theorem, Cauchy's theorem, transformation of stress components, stresses on oblique plane, various types of stresses, 3D Mohr's circle, strain at a point, yielding criterion, strain hardening postulates,

Measures of Deformation and Rate of Deformation: Deformation, different strain tensors, strain-displacement relation in curvilinear coordinate, transformation of strain components, types of strain, incremental strain tensor, rate of deformation tensor, spin tensor, compatibility condition,

Elastic-Plastic Constitutive Relations: Elastic stress-strain relations for small deformation, Experimental elastic plastic behaviour, yielding of isotropic materials, isotropic strain hardening, elastic-plastic stress-strain and stress-strain rate, theorem of limit analysis, uniqueness theorem, Slip line field theory

Eulerian and updated Lagrangian Formulations: Eulerian formulation, governing equation for elasto-plastic and rigid –plastic material, boundary conditions, updated Lagrangian formulation governing equation and boundary condition, Example on updated Lagrangian formulation, plastic analysis problems, solutions of elastoplastic problems

Plastic Anisotropy: Introduction, normal and planar anisotropy, Hill's anisotropic yield criteria, plane stress anisotropic yield criterion, 3D anisotropic yield criteria, plane strain anisotropic yield criteria, constitutive relations for anisotropic materials, kinematic hardening

BOOKS RECOMMENDED:

1. Dixit P M and Dixit U S, "Plasticity Fundamentals and Applications", CRC Press, 2014
2. Chakrabarty J, "Theory of Plasticity", Elsevier, 2008.
3. Cottrell A H, "Dislocations and plastic flow in crystals", Oxford University Press, 1965.
4. Kachanov M, "Fundamentals of the Theory of Plasticity, Dover Publications"; Dover Ed edition L., 2004.
5. Lubliner J, "Plasticty Theory", 2008.

ONLINE RESOURSES

1. Theory of Plasticity, NPTEL course, Professor Pradeep K. Jha, IIT Roorkee: https://archive.nptel.ac.in/courses/112/107/112107250/

IP-575 TRIBOLOGY [3-0-0-3]

COURSE OUTCOMES

At the end of the course, students will be able to:
CO1: To understand the importance of friction, wear and lubrication of contacting surfaces.
CO2: To understand the mechanism of different forms of wear.
CO3: To describe the various forms of lubrication.
CO4: To measure the Micro/ Nano technology using industrial applications.

DETAILED SYLLABUS

Industrial significance of tribology - Strength and deformation properties of solids – physiochemical characteristics of solid surfaces –fracture-modes of fracture- ductile-brittle-Analysis of surface roughness - measurement.

Friction - classification - Adhesion theory of friction - Elastic, plastic and visco - elastic effects in friction - rolling friction - friction of materials - alloys - ceramics - polymers - Interface temperature of sliding surfaces - measurement.

Wear - forms of wear-abrasive wear – adhesive wear - erosive wear -cavitation wear -corrosive wear-oxidative wear- fatigue wear - melting wear - diffusive wear – mechanisms - wear of nonmetallic materials.

Lubrication –types of lubrication-hydro dynamic lubrication - Reynolds equation –hydrostatic lubrication - bearing analysis – elastohydrodynamic lubrication - solid lubrication – boundary lubrication.

Micro/nano tribology - Measurement techniques - Surface Force Apparatus (SFA) - Scanning Probe Microscopy - Atomic Force Microscopy (AFM)-Nano-mechanical Properties of Solid Surfaces and Thin Films - Computer Simulations of Nanometer-Scale Indentation and Friction.

TEXT BOOKS:

1. I.M. Hutchings, "Tribology: Friction and Wear of Engineering Materials", Elsevier Limited, 1992.

2. G. W. Stachowiak, A. W. Batchelor, "Engineering Tribology", Elsevier Limited, 2005.

3. K.C. Ludema, "Friction, wear, lubrication: A text book in tribology", CRC Press, 1996.

4. Bharat Bhushan, "Principles and applications of tribology", John Wiley & Sons, 1999.

5. Bharat Bhushan, "Nanotribology and Nanomechanics: An Introduction", Springer, 2008.

ONLINE RESOURCES:

Tribology - (Mechanical Engineering course from IIT Delhi) NPTEL Lecture Videos by Dr. Harish Hirani from IIT Delhi: http://www.nptelvideos.com/course.php?id=883

IP-576 WELDING METALLURGY [3- 0 -0 -3]

COURSE OUTCOMES

CO1. Students will learn and understand the basics of heat flow, fluid flow and solidification concepts of the welded joints.

CO2. Students will be able to apply the basics of heat flow, fluid flow and solidification concepts to solve the numerical problems.

CO3. Students will be trained to apply the concepts of metallurgy to analyze the welding metallurgy of ferrous and non-ferrous materials.

CO4. Students will learn the basic weld defects and understand the various weldability tests applied for evaluating the properties of weldments.

DETAILED SYLLABUS

Thermal cycles & fluid flow

Heat flow - temperature distribution-cooling rates - influence of heat input, joint geometry, plate thickness, preheat, significance of thermal severity number, fluid flow in arcs and weld pools, metal evaporation

Solidification

Epitaxial growth, weld metal solidification, columnar structures and growth morphology, effect of welding parameters, absorption of gases, gas/metal and slag/metal reactions

Welding metallurgy of ferrous materials

Phase transformations- weld CCT diagrams - carbon equivalent-preheating and post heating-weldability of low alloy steels, welding monograms; welding of stainless steels (austenitic, ferritic, martensity, duplex and PH stainless steels), use of Schaffler and Delong diagrams, welding of cast irons – microstructures, defects and remedial measures

Welding metallurgy nonferrous materials

Welding of Cu, Al, Ti and Ni alloys: processes, difficulties, microstructures, defects and remedial measures

Weld defects and weldability tests

Origin - types - process induced defects, - significance - remedial measures, Hot cracking - cold cracking -lamellar tearing - reheat cracking - weldability tests - effect of metallurgical parameters

TEXT BOOKS:

1. Linnert G E.,"Welding Metallurgy", Volume I and II, 4th Edition, AWS, 1994
2. Granjon H, "Fundamentals of Welding Metallurgy", Jaico Publishing House, 1994
3. Kenneth Easterling, "Introduction to Physical Metallurgy of Welding", 2nd Edition, Butterworth Heinmann, 1992
4. Saferian D., "The Metallurgy of Welding", Chapman and Hall, 1985
5. Jackson M D, "Welding Methods and Metallurgy", Grffin, London, 1967
6. Norman Bailey, "Weldability of Ferritic Steels", Jaico Publishing House, 1997
7. Kou S., "Welding Metallurgy: John Wiley, 1987

ONLINE RESOURSES

1. Welding Metallurgy, NPTEL course, Professor Swarup Bag, IIT Guwahati: https://nptel.ac.in/courses/112103244/17

IP-577 BIG DATA ANALYTICS FOR MANUFACTURING [3-0-0-3]

Course Objective

This course intends to train the students in various concepts of big data analytics like Big Data Platforms, Apache Hadoop Ecosystem, HDFS and Map Reduce and to make them industry ready to take up jobs in this field.

Course Outcomes:

CO1: The students will be able to Describe big data and use cases from selected business domains
CO2: The students will be able to List the components of Hadoop and Hadoop Eco-System
CO3: The students will be able to Access and Process Data on Distributed File System
CO4: The students will be able to Manage Job Execution in Hadoop Environment
CO5: The students will be able to Develop Big Data Solutions using Hadoop Eco System

DETAILED SYLLABUS

Section A

Introduction to Big Data and Hadoop: Types of Digital Data – Introduction to Big Data – Big Data Analytics – History of Hadoop – Analysing Data with Hadoop – Hadoop Streaming – Hadoop Eco System – Applications of Big Data: marketing – fraud detection – risk assessment – credit risk management – healthcare – medicine – advertising.

HDFS (Hadoop Distributed File System): Design of HDFS – HDFS Concepts – Command Line Interface – Hadoop file system interfaces – Data flow – Data Ingest with Flume and Sqoop – Hadoop I/O: Compression – Serialization – Avro and File-Based Data structures.

Section B

Map Reduce: Anatomy of a Map Reduce - Job Run – Failures – Job Scheduling – Shuffle and Sort – Task Execution – Map Reduce Types and Formats – Map Reduce Features - Composing map reduce calculations.

Hadoop Ecosystem: Introduction to PIG – Execution Modes of Pig – Comparison of Pig with Databases – Grunt – Pig Latin – User Defined Functions – Data Processing operators - Hbase – data model and implementations – Hbase clients – Hbase examples – Hive – data types and file formats – HiveQL data definition – HiveQL data manipulation – HiveQL queries.

Section C

Mining Data Streams: Stream Data Model – Sampling Data in the Stream – Filtering Streams – Counting Distance Elements in a Stream – Estimating Moments – Counting Ones in Window – Decaying Windows.

Case studies on applications of big data analytics in manufacturing areas like yield improvement, risk evaluation, tool optimization, supply chain management etc.

REFERENCES:

1. Tom White "Hadoop: The Definitive Guide" Third Edition, O'reily Media, 2012.
2. Seema Acharya, Subhasini Chellappan, "Big Data and Analytics" Wiley Publication, 2015.

3. Raj Kamal, Preeti Saxena, "Big Data Analytics: Introduction to Hadoop, Spark, and Machine Learning", McGraw Hill, 2018.
4. Jay Liebowitz, "Big Data and Business Analytics" CRC press, 2013.
5. Bill Franks, "Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Archana Mire, Advanced Analytics", John Wiley & sons, 2012.
6. Jure Leskovec, Anand Rajaraman, Jeffrey Ullman. "Mining of Massive Datasets." Cambridge University Press. 2014.

IP-578 CYBER SECURITY FOR MANUFACTURING [3-0-0-3]

COURSE OUTCOMES:

1. Understand the fundamental concepts and terminology of cybersecurity
2. Recognize common cyber threats and attacks and learn techniques for mitigating them
3. Understand the principles of risk assessment and management
4. Understand the basics of cryptography and cryptographic algorithms
5. Understand the principles of network security and access control
6. Learn how to conduct incident response and disaster recovery

DETAILED SYLLABUS

Introduction to Cybersecurity
Cybersecurity concepts and terminology, Historical overview of cyber threats and attacks, Current trends and challenges in cybersecurity

Threat Analysis and Risk Assessment
Threat modeling and analysis techniques, Risk assessment methodologies and tools, Risk management strategies and best practices

Security Policies and Access Control
Security policies and standards, Access control models and mechanisms, Identity and access management (IAM)

Cryptography
Cryptographic algorithms and protocols, Public key infrastructure (PKI), Digital signatures and certificates

Network Security
Network security protocols and architectures, Firewalls, intrusion detection and prevention systems (IDPS), Virtual private networks (VPN)

Incident Response and Disaster Recovery
Incident response planning and preparation, Incident response procedures and best practices, Disaster recovery planning and implementation

References:

"Cybersecurity Essentials" by Charles J. Brooks and Christopher Grow

"Computer Security: Principles and Practice" by William Stallings and Lawrie Brown.

IP-579 ADVANCED COMPUTATIONAL TECHNIQUES [3-0-0-3]

COURSE OUTCOMES:

1. Understand the basic principles of numerical analysis and computational techniques.
2. Apply numerical methods to solve engineering and scientific problems.
3. Develop and implement algorithms for solving nonlinear equations, optimization problems, linear and nonlinear systems of equations, and differential equations.
4. Analyze the accuracy and stability of numerical algorithms.
5. Use software packages to implement numerical algorithms and solve engineering and scientific problems.

DETAILED SYLLABUS

Unit 1: Introduction to Numerical Analysis

Introduction to numerical analysis and computational techniques, Sources of errors in numerical computations, Error analysis and propagation

Unit 2: Nonlinear Equations and Optimization

Bisection method, Newton-Raphson method, Secant method, Golden section search, Gradient-based optimization

Unit 3: Linear and Nonlinear Systems of Equations

Gaussian elimination, LU decomposition, Newton's method for systems of equations, Quasi-Newton methods, Broyden's method

Unit 4: Numerical Integration and Differentiation

Trapezoidal rule, Simpson's rule, Romberg integration, Finite difference methods, Richardson extrapolation

Unit 5: Numerical Solutions of Ordinary and Partial Differential Equations

Euler's method, Runge-Kutta methods, Finite difference methods for differential equations, Finite element methods for differential equations, Applications of numerical methods in engineering and science

Reference Books:

Chapra, S. C., & Canale, R. P. (2014). Numerical Methods for Engineers (7th ed.). McGraw-Hill Education.

IP-580 DESIGN AND ANALYSIS OF EXPERIMENTS [3-0-0-3]

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1: Apply basic statistics techniques including ANOVA and regression

CO2: Create the experimental designs such as RCBD, BIBD, Latin Square, factorial and fractional factorial designs

CO3: Use application of statistical models in analysing experimental data

CO4: Apply RSM and Taguchi to optimize response of interest from an experiment

CO5: Apply Robust design of process and product for the real time applications

DETAILED SYLLABUS

Section A

Experimental design fundamentals: Importance of experiments, experimental strategies, basic principles of design, terminology, steps in experimentation, sample size, Basic statistics, Regression, ANOVA.

Experimental designs: Completely randomized design, RCBD, Latin square, Balanced Incomplete block design (BIBD), Estimation of model parameters, Model adequacy checking, Pair wise comparison tests. (15 Hours)

Section B

Factorial designs: Full factorial designs, 2 k factorial designs, Blocking and confounding in 2 k factorial designs, 2 k - p factorial designs, Fractional factorial design, nested designs, Split plot design.

Response surface methodology: Introduction to Response Surface Methodology, Experiments with random factors, rules for expected mean squares, approximate F-tests, method of steepest ascent, Analysis of second order responses, Multiple responses. (15 Hours)

Section C

Taguchi Methods: Steps in experimentation, design using orthogonal arrays, data analysis, robust design/ control and noise factors, S/N ratios, parameter design, case studies.

Robust Design: Crossed array design, Combined array design. (10 Hours)

Reference Books:

1. Design and Analysis of Experiments by D C Montgomery, Wiley
2. Applied Statistics and Probability for Engineers by D C Montgomery and G C Runger, Wiley
3. Design of Experiments-An Introduction Based on Linear Models by M D Morris, CRC Press.

IP-581 SUSTAINABLE MANUFACTURING [3-0-0-3]

COURSE OUTCOMES:

CO1: Understand the concept of sustainable manufacturing

CO2: Utilise tools and techniques of sustainable manufacturing

CO3: Perform life cycle assessment and assess environmental impacts of manufacturing processes

CO4: Compare various processes and products for sustainability using software packages

DETAILED SYLLABUS

Part 1: Introduction to Sustainable Manufacturing, Hazardous Waste Management and Recyclability

Introduction to sustainable manufacturing – Origins of sustainable manufacturing – Sustainable manufacturing concepts – Indian/European/US environmental policies – Legislative, cultural, societal and political issues – Sustainable quality systems – Emission less manufacturing - Comparison between green, eco-manufacturing, eco- machining, clean manufacturing and sustainable manufacturing, Concept of triple bottom line, environmental, economic and social dimensions of sustainability. Introduction to hazardous management in industries – Need for hazardous waste management -Appropriate method of collection, storage, transport and disposal of hazardous waste – Hazardous waste prevention and Life cycle assessment – Advantages and limitations of hazardous management – Recyclability: Recycling, recharging, disassembly, recovery, remanufacturing – End-of-life and product take-back issues – Training of next generation workforces for sustainable manufacturing.

Part 2: Life Cycle Assessment (LCA)

Introduction to Environmental Life cycle Assessment (LCA),ISO 14040, ISO 14044, Goal and Scope definition, Functional Unit, Inventory Analysis, Impact assessment, Interpretation, Environmental indicators and LCA models, Environmental impact assessment methods- CML, EI 95 and 99, ISO 14001, EMS and PAS 2050 standards, environmental impact parameters, Application of LCA in manufacturing industry (CASE STUDIES), Introduction to Life Cycle Costing (LCC) and Social Life Cycle Assessment (SLCA).

Part 3: Hands on Project

In this phase, the students will take up individual practical problems and assess using LCA tools and deliver their presentations

Textbook(s)

Atkinson G, Dietz S, Neumayer E, "Handbook of sustainable manufacturing" Edward Elgar Publishing limited, 2007

Rodick, D, "Industrial Development for the 21 st century: Sustainable development perspectives" UN New York,2007

Reference(s)

Lawn.P, "Sustainable development indicators in ecological economics", Edward Elgar Publishing limited, 2006

Asefa, "The economics of sustainable development", WE Upjohn institute for employment research, 2005

Dornfeld, David (Ed), "Green manufacturing: fundamentals and applications", Springer Science

& Business Media,2012
Klemes J, "Sustainability in the process industry", McGraw Hill,2011

IP-582 MATERIALS ENGINEERING AND CHARACTERIZATION [3-0-0-3]

COURSE OUTCOMES

At the end of the course students will be able to:

CO1. Understand the fundamental concepts of materials engineering.

CO2. Apply the materials engineering concepts to solve complex numerical problems in crystallography, diffusion and solidification.

CO3. Apply the basic concepts of materials engineering to understand the mechanism of phase transformations in metals and alloys.

CO4. Learn and understand the basic failure mechanisms and characterization techniques used for metals and alloys.

CO5. Apply characterization techniques to analyze the different microstructural constituents within an alloy.

CO6. Evaluating the properties of materials and failure mechanisms through material characterization techniques.

DETAILED SYLLABUS

Crystallography: space lattice - unit cell - classification of space lattices by crystal system - packing factor - indexing of crystal planes and directions in cubic and hexagonal system - defects in crystals - dislocation concepts - slip and twin crystal orientation, Strengthening mechanisms.

Diffusion: Atomic mechanisms of diffusion, Interstitial diffusion, Substitutional diffusion, Atomic mobility, Diffusion in binary alloys, Diffusion in ternary alloys, High diffusivity paths, Diffusion in multiphase binary systems.

Solidification: Nucleation and Growth in pure metals, Concept of free energy, Nucleation and crystal growth during solidification, Homogeneous nucleation, critical size of the nucleus, Solidification of ingots and castings, Solidification of fusion welds, Coring and segregation.

Phase Transformation of Metals and Alloys:

Understanding the basics of binary phase diagrams, Introduction to iron-iron carbide diagram, TTT and CCT diagrams, Precipitate growth, Precipitation in Age-Hardening alloys, Precipitation of ferrite, pearlite, bainite and martensite from austenite, Cellular precipitation, Recovery, recrystallization and grain growth. Introduction to the ternary phase diagram.

Failure and characterization of metals and alloys:

Fundamentals of fracture, Principles of fracture mechanics, Introduction to impact fracture testing, fatigue and creep, Optical microscopy, Surface analysis, Electron microscopy, Diffraction methods of characterization.

TEXT BOOKS:

1. William Callister, "Materials science and engineering- An introduction", Wiley, 2007.
2. William F Hosford, "Physical metallurgy", CRC press, 2005.
3. V Raghavan, "Phase transformations", 2006.

REFERENCE BOOKS:

1. Porten and Easterting, "Phase Transformation".
2. R W Cahn, "Phase Transformation".
3. R E Smallman, "Modern Physical Metallurgy".
4. Reedhill RE, "Principles of Physical Metallurgy".

ONLINE RESOURCE

1. Physical Metallurgy, NPTEL Course, Professor Rabindra Nath Ghosh, IIT Kharagpur: https://nptel.ac.in/courses/113105024/

IEA- 505 Modelling & Simulation [3-0-0-3]

COURSE OUTCOMES:

CO1: Describe the role of important elements of discrete event simulation and modeling paradigm.

CO2: Conceptualize real world situations related to systems development decisions, originating from source requirements and goals.

CO3: Develop skills to apply simulation software to construct and execute goal-driven system models.

CO4: Interpret the model and apply the results to resolve critical issues in a real world environment.

Definitions of manufacturing with input-output model, Introduction to systems and modeling, System Modeling Issues, System Modeling Tools and Techniques: Introduction to mathematical modeling, optimization, and simulation; Issues related with deterministic and stochastic models; Continuous and discrete mathematical modeling methods

Random Numbers: Random number generation, Properties of Random Numbers, Generation of Pseudo Random Numbers, Techniques –Tests for Random Numbers

Random variates generation, Inverse Transform Technique, Direct Transform Techniques Convolution Method, Acceptance Rejection Technique, Routines for Random Variate Generation

Discrete Event Monte Carlo Simulation: Simulation of Single Server Queuing System. Simulation of manufacturing shop floor system, Simulation of Inventory System, Modeling of absorbing states and deadlocks; Conflicts; Concurrency, and synchronization etc., Basic concepts of Markov chains and processes; Models of manufacturing systems, introduction to Petri nets.

Data Input Modelling: Data collection, Identification and distribution with data, parameter estimation, Goodness of fit tests, Selection of input models without data, Multivariate and time series analysis.

Verification and Validation of Model – Model Building, Verification, Calibration and Validation of Models.

Output Analysis: Types of Simulations with Respect to Output Analysis, Stochastic Nature of output data, Measures of Performance and their estimation, Output analysis of terminating simulation, Output analysis of steady state simulations.

Simulation languages and packages-Case studies in FLEXSIM, ARENA, Modeling and Simulation with Petrinets, case studies in manufacturing systems

References

1. Jerry Banks & John S.Carson, Barry L Nelson, "Discrete event system simulation" ,Prentice Hall (5th Edition)
2. Law A.M, "Simulation Modeling and Analysis", Tata Mc Graw Hill (5th Edition)
3. Narsingh Deo, " System Simulation with Digital Computer", PHI Learning
4. Pidd, M, "Computer Simulation in Management Science", John Wiley & Sons, Inc. (5th Edition)
5. Geoffrey Gordon, System Simulation, Prentice Hall publication, (2nd Edition)

IEA-507 Work System Design [3-0-0-3]

COURSE OBJECTIVES

1. To provide basic understanding and impart thorough knowledge to the students about application of work-study and Ergonomics tools for improving the productivity of an organization.
2. To inculcate the skill among the students for analyzing and improving existing methods of working and allowances, rating, calculation of basic and standard time for manual operations on the shop floor of an organization.
3. To inculcate analyzing skills among the students and apply Human Factors Engineering and Ergonomics with respect to design work place and working with safety, comfort and efficiency.

COURSE OUTCOMES

CO1. Students will be able to calculate the basic work content of a specific job for employees of an organization. Thereby they will be able to calculate the production capacity of man power of an organization.

CO2. Students will be able to analyze and calculate the level of risk in a job causing stress, fatigue and musculoskeletal disorders and design appropriate work systems.

CO3. Students will be able to rate a worker engaged on a live job and calculate basic, allowed and standard time for the same.

CO4. Students will be able to analyze the existing methods of working for a particular job and develop an improved method through questioning technique.

CO5. Students will be able to provide appropriate allowances for the jobs under analysis.

DETAILED SYLLABUS

Introduction: Productivity, definition and scope of motion and time study, history of motion and time study, work method design, human factor in the application of work study, man-machine interface.

Motion study: concept, operation process chart, flow chart, multiple activity charts, travels chart, flow diagram, and operation analysis. Micro motion study, memo motion study, cycle graphic and chronocyclegraph analysis, fundamental hand motions, therbligs, micro motion study equipment, film analysis- SIMO charts, principles of motion economy.

Time study: concept, uses of time study, time study equipment, making the time study, work sampling, determination of sample size, procedure for selecting random observations, errors in work sampling.

Rating factors and allowances: the concept of qualified worker, the average worker, standard rating and standard performance, definition of rating, systems of rating, rating of efforts, scales of rating, introduction to allowances, classification of allowances, applying the allowances, determining the time standards, predetermining time standards (PTS), standard data, the uses of time standards, MTM-I, MTM-II.

Principles of workplace design, physical requirements in the workplace anthropometrics and communication considerations, social requirements of the workplace- personal and territoriality considerations. Workspace design; general principles, deciding position of control with respect to

other controls, position of displays with respect to other displays, positioning of displays and controls, control display compatibility.

Ergonomics: Introduction, definition, objectives and scope, man-machine system and its components. Introduction to musculoskeletal system, respiratory and circulatory system, metabolism, measure of physiological functions- workload and energy consumption, Introduction to biomechanics, types of movements of body members, Design of lifting tasks using NIOSH lifting equation, Distal upper extremities risk factors, risk assessment tools; Strain Index, RULA, REBA. Introduction to anthropometry; work table and seat designing. Design of Visual displays and controls. Occupational exposure to; noise, whole body Vibrations, heat stress and dust. Effect of vibration/ noise, temperature, illumination and dust on human health and performance. Occupational Health and safety, Relationship between safety, health and productivity

TEXT BOOKS

1. Barnes Ralph M., "Motion & Time study: Design and Measurement of Work", Wiley Text Books, 2001.
2. Marvin E, Mundel & David L, "Motion & Time Study: Improving Productivity", Pearson Education, 2000.
3. Benjamin E Niebel and Freivalds Andris, "Methods Standards & Work Design", Mc Graw Hill, 1997.
4. Lakhwinder P S, "Work Study and Ergonomics", Cambridge University Press, 2016

REFERENCE BOOKS

1. International Labour organization, "Work-study", Oxford and IBH publishing company Pvt. Ltd., N.Delhi, 2001.
2. Sanders Mark S and McCormick Ernert J, "Human Factors in Engineering and Design", McGraw- Hill Inc., 1993.
3. KjellZandin, Maynard's Industrial Engineering Handbook, Fifth Edition, McGraw Hill, 2001.

IEA-509 Advanced Operation Research [3-0-0-3]

COURSE OBJECTIVES

The objective of this course is to develop an ability in the students to understand and analyze managerial problems in industry so that they are able to use resources (capitals, materials, staffing, and machines) more effectively, develop skills for formulating mathematical models and solving these problems.

COURSE OUTCOMES

CO1. Students shall be able to use variables for formulating complex mathematical models in management science, industrial engineering and transportation science.
CO2. Students will be able to use various software packages such as Lingo, Solver, and TORA for solving linear programming and integer programming models.
CO3. Students will be able to solve problems related with transportation and assignment problems, queuing theory etc. by traditional algorithms and also by using linear programming approach.
CO4. Understand and apply different algorithms for solving goal or integer programming, nonlinear programming problems.
CO5. Understand genetic algorithms, Binary/Real coded GAs for constrained optimization, and simulated annealing, ant colonies, particle swarm optimization.

DETAILED SYLLABUS

The simplex algorithm, duality, sensitivity analysis-changes in right- hand side constants of constraints-changes in objective function co-efficient-adding a new constraints-adding a new variable. Transportation algorithm and optimality, assignment model, Hungarian method. Model development for using LPP approach for solving Transportation and Assignment Problems using Excel Solver. Decision making under risk and uncertainty, game theory, two-person zerosum game, mixed strategy. Integer programming algorithm – Cutting plane algorithm- Zero-one implicit enumeration algorithm. One dimensional cutting stock problem. Goal programming formulations. Nonlinear programming problems. Network models, shortest path problems, Maximum flow problem, Branch and Bound algorithm and heuristics for travelling salesman problem, Vehicle routing problems, Chinese postman problem. Single and multiple server queuing models.

Recommended Books

1. Taha, H.A., Operations Research - An Introduction, Sixth Edition, Prentice Hall of India Private Limited, N. Delhi, 1997.
2. Hillier, F.S., Operations Research, First Indian Edition, CBS Publishers and Distributors, Delhi, 1994.
3. Wagner H.M., Principles of Operations Research, Second Edition, Prentice Hall of India Private Limited, New Delhi, 1996.
4. G.Srinivasan , "Operations Research Principles and Applications" ,PHI 2008.
5. Panneerselvam ,R, "Operations Research", Prentice – Hall of India, New Delhi,2002.

IEA-521 Project Management [3-0-0-3]

COURSE OBJECTIVE

1. To provide basic and some advanced exposure to enable the students to successfully complete sophisticated projects within the constraints of capital, time, and other resources.
2. To enable the students to prepare networks based time schedules and analyse the project activities.
3. To enable the student to practice project management with ethics.

COURSE OUTCOMES

1. To understand the concepts of project definition, life cycle, and systems approach;
2. To develop competency in project scoping, work definition, and work breakdown structure (WBS);
3. To handle the complex tasks of time estimation and project scheduling, including PERT and CPM
4. To develop competencies in project costing, budgeting, and financial appraisal;
5. To gain exposure to project control and management, using standard tools of cost and schedule variance analysis;
6. To appreciate and understand the use of computers in project management, especially a software like MS Project.

DETAILED SYLLABUS

Introduction: concept and definition of a project, categories of projects, project life cycle phases, project visibility, roles and responsibility of project manager.

Project planning and analysis: Generation of ideas, monitoring the environment, corporate appraisal, scouting for project ideas, preliminary screening, project rating index, sources of positive net present value. Market and demand analysis, technical analysis, project cash flows, social cost benefit analysis, project viability. The statement of work, project specifications, work breakdown structure. Contracting in projects, types of contracts. Organization planning, project versus non-project organization, matrix form of organization.

Project scheduling: Gantt chart, milestone chart, limitations of Gantt and milestone charts. Development of the network, activity on node and activity on arc network precedence diagrams, Fulkerson's flow algorithm, topological ordering, redundancy removal, tackling cycles in the network. Isolating critical path, multiple critical paths. Determination of the floats: total float, safety float, free float and independent float. Decision CPM, Generalized activity networks, GERT.

The PERT model: event orientation, uncertainty, the PERT assumptions, variability of the activity times, expected times for activities, expected length of the critical path, invoking central limit theorem, due date probability, limitations of network models.

Time-cost trade off: cost versus time, straight-line approximation of variation of cost with reduction in time for activities, direct and indirect costs. Contracting the network: fixed project

duration and corresponding total cost, optimum project duration and minimum project cost, project cost curve.

Network cost accounting: cumulative costs for early and late start schedules, range of feasible budgets, graphic display of cost and time data, time and cost overrun or underrun in projects.

Scheduling with limited resources: the complexity of the project scheduling with limited resources, heuristic programs, resource leveling and resource allocation in project scheduling. Information requirements for projects, project management software based application using Microsoft Project, Primavera.

TEXT BOOKS

1. Kerzner Harold, "Project Management - A Systems Approach to Planning, Scheduling and Controlling", CBS Publishers Delhi, Second edition (2002).
2. Weist Jerome D and Ferdinand K. Levy, "A Management Guide to PERT/CPM with GERT/PDM/DCPM and other networks", Prentice-Hall of India New Delhi, Second edition (2003)
3. Parsanna Chandra, "Project Planning, Analysis, Selection, Implementation and Review", Tata McGraw Hill, Fourth Edition (2002)

REFERENCE BOOKS

1. Srinath L.S., "PERT & CPM Principles and Applications", Affiliated East- West Press Pvt. Ltd., New Delhi, Third Edition (1993)
2. Ghattas R G and Sandra L Mckee, "Practical Project Management" Pearson Education Asia, First edition (2004).
3. PMI, A guide to Project Management body of knowledge, 2000.

ONLINE RESOURSES

1. Coursera Course, "Introduction to Project Management Principles and Practices Specialization",
2. https://www.coursera.org/specializations/project-management
3. Coursera Course "Professional Certificate in Applied Project Management",
4. https://www.coursera.org/professional-certificate/applied-project-management
5. Project management Institute, https://www.pmi.org/
6. Project and Production Management, NPTEL course by Prof. Arun Kanda, Department of Mechanical Engineering, Indian Institute of Technology, Delhi , https://nptel.ac.in/courses/112102106/

IEA-523 PRODUCT DESIGN AND DEVELOPMENT [3-0-0-3]

COURSE OUTCOMES

CO1: understand manufacturing attributes of an industry and classify various plant layouts
CO2: analyse various location choices to select an appropriate location for manufacturing and services
CO3: design a process layout through various strategies
CO4: design a product layout through various strategies
CO5: design a group technology based layout through various strategies
CO6: identify and analyse the problems in the existing layout/material handling system and suggest appropriate material handling strategies

DETAILED SYLLABUS

- **Need for Developing Products:** The importance of engineering design-types of design-the design process-generic product development process-various phases of product development-planning for products- Adapting the Generic Product Development Process
- **Opportunity Identification:** What is an Opportunity, Types of Opportunities, Tournament Structure of Opportunity, Identification, Opportunity Identification Process
- **Product Planning and Identifying Customer Needs:** The Product Planning Process, The Importance of Latent Needs, The Process of Identifying Customer Needs-gather raw data – Interpret raw data- organize the needs into a hierarchy – Relative importance of the needs.
- **Product Specifications and Concept Generation, Selection & Testing:** Specifications-Specifications Establishment, Refining specifications, Target Specifications. A Five-Step Method: Clarify the Problem, Search internally – Search externally – Explore systematically. Concept Screening – Concept Scoring – Concept Testing.
- **Product Architecture**: Types of Modularity, Implication of architecture – Establishing the architecture, Delayed Differentiation, Platform Planning
- **Industrial Design:** Need for industrial design – Impact of industrial design – Industrial design process – Management of industrial design process – Assessing the quality of industrial design.
- **Prototyping:** Principles of Prototyping – Types of Prototypes – Planning for Prototypes, Prototyping Technologies: 3D CAD Modeling and Analysis, 3D Printing: Advantages and Drawbacks
- **Design for Manufacturing and Assembly:** Overview of the DFMA Process, Materials selection, process considerations, and design guidelines for manufacturing.
- **Patents and Intellectual Property**: Intellectual Property, Overview of Patents-Utility Patents Preparing a Disclosure-Formulate a Strategy and Plan - Timing of Patent Applications- Type of Applications- Scope of Application- Study Prior Inventions- Outline Claims-Write the Description of the Invention-Defensive Disclosure, Refine Claims, Writing the Claims, Guidelines for Crafting Claims
- **Economics of Product Development:** Elements of Economic Analysis, Economic Analysis Process

- **Value Engineering:** Origin of Value Engineering, Meaning of Value, Definition of Value Engineering, Types of Value, Function - Basic and Secondary functions, Seven Phases of Job Plan, FAST Diagram as Value Engineering Tool, Benefits of Value Engineering.

TEXT BOOKS

7. Karl, T. Ulrich Steven D. Eppinger, "Product Design and Development", McGraw Hill, International Editions, 2003.
8. Mudge, Arthur E. "Value Engineering"- A systematic approach, McGraw Hill, New York, 2000.
9. Clive L.Dym, Patrick Little, "Engineering Design: A Project-based Introduction", 3rd Edition, John Wiley & Sons, 2009, ISBN 978-0-470-22596-7
10. George E.Dieter, Linda C.Schmidt, "Engineering Design", McGraw-Hill International Edition, 4th Edition, 2009, ISBN 978-007-127189-9
11. Kevin Otto, Kristin Wood, "Product Design", Indian Reprint 2004, Pearson Education,ISBN 9788177588217
12. Yousef Haik, T. M. M. Shahin, "Engineering Design Process", 2nd Edition Reprint, Cengage Learning, 2010, ISBN 0495668141

REFERENCE BOOKS

1. S.Rosenthal, "Effective Product Design and Development", Irwin, 1992.
2. Charles Gevirtz, "Developing New products with TQM", McGraw Hill, International Editions, 1994.

ONLINE RESOURSES

Product design and Development, NPTEL course, Prof. Inderdeep Singh, Department of Mechanical and Industrial Engineering Indian Institute of Technology (IIT), Roorkee.
https://onlinecourses.nptel.ac.in/noc17_me16/preview

IEA-526 OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT [3 0 0 3]

COURSE OBJECTIVES

The main objective of this course is to make the students aware of occupational health and safety issues in the industries, environmental laws, safety management laws and their applications.
To provide knowledge and skill about conventional and advanced strategies for occupational protection, and occupational health assessment methods.

COURSE OUTCOMES

CO1. Students will understand the basic laws related to environmental and safety management in the industries.
CO2. Students will be able to formulate and implement new strategies for assuring health and safety issues in the industries.
CO3. Students will learn the compliance requirements for the industries as per the existing regulations such as Factory Act.
CO4. Students will be able to make appropriate decisions for w.r.t. factors affecting occupational health.
CO5. Students will be able to create awareness the humans during assessment of health hazards in their working environment
CO6. Students will be able to contribute towards making efficient and more comfortable occupational Environment.

DETAILED SYLLABUS

Introduction: Concept of Occupational safety & Health, Importance of Occupational Safety & Health, Relationship between safety, health and productivity, Safety Triangle.

Safety: Influence of Plant layout & Design, Equipment Design, Workplace design on Safety, Industrial Accidents- types and causes, Cost of Accidents – Cost Analysis, Systems Safety Analysis- methods and Techniques.

Noise & vibrations: Physics of Sound, Physiology of Hearing, Acceptability Criterion, Noise Measurements, Control of Noise Exposure, Hearing Conservation Programs, Vibration in workplace- measurement & Control.

Hot & Cold Environments: Introduction, Physiology of Thermoregulation, Mechanisms of Thermal Exchange, Measuring Thermal Environment, Heat Stress Indices, Heat Exposure Limits, Assessing Environmental Strain, Controlling Thermal Exposure, Design of Local Exhaust system and general ventilation system.

Industrial Illumination: Need for lighting, relationship between illumination- safety, performance & Health. Natural & Artificial lighting sources, Characteristics of artificial lighting sources, quantity and quality of illumination, IES procedure for calculating optimum lighting requirement, recommended illumination standards for various industrial tasks.

Books Recommended:

1. Grimaldi J V, "Safety Management- 5th Edition", AITBS Publishers, Delhi, (2006).
2. McCormick J, "Human Factors in Engineering & Design- 7th Edition", McGraw Hill Publishing Company limited (1992).
3. Salvator R Dinardi- Editor, "The Occupational Environment- Its Evaluation, Control and Management", AIHA Press, Fairfax, Virginia, (2003).
4. David Goetch, "The Safety and Health Handbook", Pearson Education, (1999).