SYLLABI

OF

PhD (Mechanical Engineering)

(Choice Based Credit Scheme)

2019 - 2020

DEPARTMENT OF MECHANICAL ENGINEERING

J.C. BOSE UNIVERSITY OF SCIENCE & TECHNOLOGY, YMCA, FARIDABAD

J.C. Bose University of Science and Technology, YMCA, Faridabad

Ph.D. (Mechanical Engineering)

Scheme of Studies / Examination

Course No.	Course Title	Teaching Schedule			Marks for sessionals	Marks for End Term Examination	Total Marks	Credits
		L	T	P				
PHD-100A	Research Methodology	4	0	0	25	75	100	4
CPE-RPE	Research and Publication Ethics	2	0	0	25	75	100	2
	Elective-I	4	0	0	25	75	100	4
	Total	10	0	0	75	225	300	8

Elective-I

PHDME – 101A QUALITY MANAGEMENT: A SYSTEMS PERSPECTIVE
PHDME – 102A LEAN MANUFACTURING
PHDME – 103A AUTOMATION IN MANUFACTURING
PHDME – 104A FLEXIBLE MANUFACTURING SYSTEM
PHDME – 105A SUPPLY CHAIN MANAGEMENT
PHDME – 106A ENGINEERING FAILURE ANALYSIS AND PREVENTION
PHDME – 107A THERMOECONOMICS AND POWER PLANTS
PHDME – 108A APPLIED COMPUTATIONAL METHODS
PHDME – 109A PLASTICS PROCESSING AND MOULD MANUFACTURING
PHDME – 110A ADVANCED MANUFACTURING SYSTEMS
PHDME – 111A SYSTEMS RELIABILITY AND MAINTENANCE MANAGEMENT
PHDME – 112A DESIGN OF CUTTING TOOLS
PHDME – 113A COMPUTER AIDED MANUFACTURING SYSTEMS
PHDME – 114A FINITE TIME THERMODYNAMICS AND THERMOECONOMICS OF THERMAL SYSTEMS
PHDME – 115A INTRODUCTION OF COMPUTATIONAL FLUID DYNAMICS AND APPLIED SUPERCONDUCTIVITY
PHDME – 116A DATA SCIENCE
PHDME – 117A ADDITIVE MANUFACTURING
PHDME – 118A WELDING, TESTING AND CHARACTERIZATION OF MATERIALS
PHDME – 119A ADVANCED METAL CASTING

Note: The student will have to select one subject from list of Elective Courses.
Exam duration will be of 3 hours.

PHD – 100A

RESEARCH METHODOLOGY

PhD (Common Subject)

No. of Credits: 4		Sessional:	25 Marks
L | T | P | Total		Theory:	75 Marks
4 | 0 | 0 | 4		Total:	100 Marks
		Duration of Exam:	3 Hours

Course Objectives:

- Understand research process in order to plan a research proposal
- Learn methods to devise and design a research set-up
- Plan and perform data collection methods and its analysis
- Conclude research in report writing

Course Outcomes: The research scholar shall be able to

CO1 Plan a research proposal and design the research.

CO2 Collect data through experiments or surveys as per research requirement.

CO3 Understand and apply sampling and sampling distributions.

CO4 Understand and perform quantitative and qualitative data analysis.

CO5 Write research report with proper citations.

Unit 1 **Introduction to Research**: Definition, need and purpose of research, types of research, research process, approaches to research, planning a research proposal, literature review.

Unit 2 **Measurement Scales**: Indexes vs. Scales, Types of Scale, construction of Scale, Bogardus social distance scale, Thurstone Scale, Likert Scale, Semantic Differential Scale, Guttmann Scale.

Unit 3 **Data Collection Methods:** Experiments and Surveys, Experiments: Classical Experiments, Independent & Dependent Variables, Pre Testing & Post Testing, Double Blind Experiment, Subject Selection, Variation on Experiment Design. Survey Research: Topics appropriate for survey research, Guidelines for asking questions, Questionnaire Construction, Strengths & Weakness of Survey Research,

Types of Surveys.

Unit 4 **Sampling**: Types of sampling methods: Non Probability Sampling, Probability Sampling, Theory & Logic of Probability Sampling, Sampling Distributions & Estimates of Sampling Error.

Unit 5 **Data Analysis**: Qualitative v/s Quantitative data analysis, Qualitative Data Analysis: Discovering Patterns, Grounded Theory Method, Semiotics, Conversation Analysis, Qualitative Data Processing. Quantitative Data Analysis: Quantification of Data, Univariate Analysis, Bivariate Analysis, Multivariate Analysis, Regression Analysis, Description Analysis. Hypothesis. Multiple Attribute Decision Making.

Unit 6 **Report Writing, Ethical Issues and Outcomes**: Report Preparation, Structure of Report, Report Writing Skills, Citations, Research Papers, Intellectual Property Rights, Plagiarism, Patent, Commercialization, Ethical Issues.

References:

1. Research Methodology by R. Panneerselvam, 2nd Ed. PHI
2. Research Methodology by C.R. Kothari & Gaurav Garg, 3rd Ed. New Age Publishers
3. Research Methodology and Scientific Writing by C. George Thomas, Ane Books
4. The practice of social research by Earl Babbie, 14th Ed. Cengage
5. Multiple Attribute Decision Making, Gwo-Hshiung Tzeng and Jih-Jeng Huang, CRC Press

PHD – CPE-RPE

RESEARCH AND PUBLICATION ETHICS

PhD (Common Subject)

Course structure

- The course comprises of six modules listed in table below. Each module has 4-5 units.

Modules	Unit title	Teaching hours
Theory		
RPE 01	Philosophy and Ethics	4
RPE 02	Scientific Conduct	4
RPE 03	Publication Ethics	7
Practice		
RPE 04	Open Access Publishing	4
RPE 05	Publication Misconduct	4
RPE 06	Databases and Research Metrics	7
	Total	**30**

Syllabus in detail

THEORY

- **RPE 01: PHILOSOPHY AND ETHICS (3 hrs.)**

1. Introduction to philosophy: definition, nature and scope, concept, branches
2. Ethics: definition, moral philosophy, nature of moral judgements and reactions

- **RPE 02: SCIENTIFICCONDUCT (5hrs.)**

1. Ethics with respect to science and research
2. Intellectual honesty and research integrity
3. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP)
4. Redundant publications: duplicate and overlapping publications, salami slicing
5. Selective reporting and misrepresentation of data

- **RPE 03: PUBLICATION ETHICS (7 hrs.)**

1. Publication ethics: definition, introduction and importance
2. Best practices / standards setting initiatives and guidelines: COPE, WAME, etc.
3. Conflicts of interest
4. Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types
5. Violation of publication ethics, authorship and contributorship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals

PRACTICE

- **RPE 04: OPEN ACCESS PUBLISHING(4 hrs.)**

1. Open access publications and initiatives
2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies
3. Software tool to identify predatory publications developed by SPPU
4. Journal finder / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

- **RPE 05: PUBLICATION MISCONDUCT (4hrs.)**

A. Group Discussions (2 hrs.)

1. Subject specific ethical issues, FFP, authorship
2. Conflicts of interest
3. Complaints and appeals: examples and fraud from India and abroad

B. Software tools (2 hrs.)

Use of plagiarism software like Turnitin, Urkund and other open source software tools

- **RPE 06: DATABASES AND RESEARCH METRICS (7hrs.)**

A. Databases (4 hrs.)

1. Indexing databases
2. Citation databases: Web of Science, Scopus, etc.

B. Research Metrics (3 hrs.)

1. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score
2. Metrics: h-index, g index, i10 index, altmetrics

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PHDME – 101A

QUALITY MANAGEMENT: A SYSTEMS PERSPECTIVE

PhD (Mechanical Engineering)

No. of Credits: 4		Sessional:	25 Marks
L | T | P |Total		Theory:	75 Marks
4 | 0 | 0 | 4		Total:	100 Marks
		Duration of Exam:	3 Hours

Course Objectives:

- Understand quality and various aspects of its evolution
- Learn quality improvement strategies in manufacturing and non-manufacturing activities
- Understand the process of implementation of different quality systems

Course Outcomes: The research scholar shall be able to

CO1 Explain the philosophy of quality management, different meanings of the quality concept and its influence.

CO2 Describe, distinguish and use various techniques and quality management tools.

CO3 Identify the elements that are part of the quality measuring and improvement process in the industry.

CO4 Explain the regulation and the phases of a quality system certification process.

Unit 1 **Introduction**: Attributes of Quality, Evolution of Philosophy of Quality Management, Quality Assurance and Total Quality Management, Models of Quality Management, Customer Value Enhancement, Product Quality Improvement

Unit 2 **Improvement Strategies**: QFD, Taguchi Methods, 7 QC tools, Statistical Process Control, Acceptance Sampling, Service Quality, Tools and Techniques of Service Quality Improvement, Quality Costs, Strategic Quality Planning

Unit 3 **Quality in Non-Manufacturing Activities**: Finance, Marketing, Human Resource Management, Administration

Unit 4 **Quality System Implementation**: ISO 9000, Quality Information Systems, Quality Audit & Reporting, Human Resource Management in TQM Environment, Case Studies

Reference Books:

1. Quality Management by Kanishka Bedi. Pub.: Oxford Press
2. Quality Management by Howard Gitlow, Rosa Oppenheim, Alan Oppenheim, David Levine. Pub: Mcgraw Hill
3. Statistical Quality Control by Eugene Grant, Richard Leavenworth. Pub: Mcgraw Hill

PHDME – 102A

LEAN MANUFACTURING

PhD (Mechanical Engineering)

No. of Credits: 4		Sessional:	25 Marks
L | T | P |Total		Theory:	75 Marks
4 | 0 | 0 | 4		Total:	100 Marks
		Duration of Exam:	3 Hours

Course Objectives:

- To acquire knowledge about lean manufacturing and its impact on outcome of the production system.

Course Outcomes: The research scholar shall be able to

CO1 Understand the concept of lean, JIT and flexible manufacturing.

CO2 Perform procedural investigation of various wastes of the manufacturing

CO3 Explore the exact impact of implementation of JIT in production system.

CO4 Expedite the implementation of lean/JIT in Indian manufacturing system.

Unit 1 **Lean Manufacturing:** History of Lean Manufacturing, Objectives of Lean Manufacturing, Key Principles of Lean Manufacturing, Key implications of Lean Manufacturing.

Unit 2 **Lean Manufacturing Concepts:** Value Creation and Waste, Main Kinds of Waste, Customer pull vs push, Pull Production Different models of Pull Production, Impact of Pull-Production on Production Planning, One piece flow Takt time and calculation, Continuous Flow, Mixing Continuous and Discontinuous Flow, Continuous Improvement, Kaizen, People Involvement, Cellular Layout, Administrative Lean.

Unit 3 **Lean Manufacturing Tools:** Standard Work, Communication of Standard Work to employee's, Standard work and flexibility, TPS and lean house, Visual Management, Quality at the Source ,Value Stream Mapping, The Five S's, Preventative Maintenance, Total Productive Maintenance, Changeover/ setup time, Batch size reduction, Production layout and point of use storage, Kanban, Production Leveling, Pacemaker, Overall Equipment Effectiveness.

Unit 4 **Lean Manufacturing Implementation:** Value Stream Mapping: Defining value, Create VSM current state and calculation of VA and NVA, Set up future state, understand gaps, identify process weakness and bottlenecks, developing action plan., Lean layout to reduce inventory, space, transportation and motion, improve information flow, Standardization work and simulation, Standard work combination table, TPM to reduce machine breakdown time, SMED to reduce changeover time, On site quality management and control of scrap and rework, 5S and visual management, Kanban and pull, Judoka, Pursue perfection and kaizen.

Unit 5 **Inventory and Quality Control under Lean manufacturing:** Principles of inventory control, Comparison of JIT/lean and large lot EOQ operations, JIT purchasing and supplier relations, New technologies supports Lean manufacturing, JIT/EOQ Models, Methodology for vendor evaluation, Performance measurement of JIT inventory control, Implementing strategy for JIT purchasing, Principles of JIT quality control, Process control charts, Quality control circles, Performance measurement of JIT quality control.

Reference books:

1. Kiyoshi Suzaki, The new shop floor management, The free press New York
2. How to implement lean manufacturing by Lonnie Wilson, Mcgraw Hill
3. Toyota Kata by Mike Rother, Mcgraw Hill, ISBN 978-0-07-163523-3

PHDME – 103A

AUTOMATION IN MANUFACTURING

PhD (Mechanical Engineering)

No. of Credits: 4		Sessional:	25 Marks
L | T | P |Total		Theory:	75 Marks
4 | 0 | 0 | 4		Total:	100 Marks
		Duration of Exam:	3 Hours

Course Objectives:

- To study various techniques of automatic material handling in a manufacturing organization.
- To study concept and interfacing of various pneumatic, hydraulic and software for automation of mechanical products /system.
- To study control strategies, modeling and simulation in a manufacturing system.

Course Outcomes: The research scholar shall be able to

CO1 Understand the effect of manufacturing automation strategies.

CO2 Analyze automated flow lines and assembly systems, and balancing the line.

CO3 Develop automated material handling and feeders for a typical production system.

CO4 Design a flexible manufacturing system and control strategies.

CO5 Understand various types of part orientation devices and escapement devices.

CO6 Develop pneumatic systems and simulation for manufacturing plant automation.

Unit 1 **Introduction:** Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations, introduction to automation productivity.

Unit 2 **Material handling systems:** Overview of Material Handling Systems- Rotary feeders, oscillating force feeder, vibratory feeder, elevator type and Centrifugal type feeders, Principles and Design Consideration, Material Transport Systems, Storage Systems.

Unit 3 **Automated Manufacturing Systems:** Components, Classification and Overview of Manufacturing Systems, Manufacturing Cells, GT and Cellular Manufacturing, FMS, FMS and its Planning and Implementation, Flow lines & Transfer

Mechanisms, Fundamentals and Analysis of Transfer Lines, product design for automatic assembly.

Unit 4 **Control Technologies in Automation:** Industrial Control Systems, Process Industries Verses Discrete-Manufacturing Industries, Continuous Verses Discrete Control, Computer Process and its Forms. Sensors, Actuators and other Control System Components.

Unit 5 **Evaluation of automatic production:** product manufacturability, orientation devices- active and passive devices, parts orientation and Rocapement.

Unit 6 **Pneumatic and hydraulic components and circuits:** Boolean algebra, pneumatic sensors and amplifiers, jet destruction devices, logic devices, schimit triggering devices, developing pneumatic circuits for automatic die casting machine.

Unit 7 **Modeling and Simulation for manufacturing Plant Automation:** Introduction, need for system Modeling, Building Mathematical Model of a manufacturing Plant, Modern Tools- Artificial neural networks in manufacturing automation, AI in manufacturing, Fuzzy decision and control, robots and application of robots for automation.

Reference Books:

1. Handbook of design, manufacturing & Automation: R.C. Dorf, John Wiley and Sons.
2. Automation, Production Systems and Computer Integrated Manufacturing, M.P. Groover, Pearson Education.
3. Industrial Automation: W.P. David, John Wiley and Sons.
4. Computer Based Industrial Control, Krishna Kant, EEE-PHI
5. An Introduction to Automated Process Planning Systems, Tiess Chiu Chang & Richard A. Wysk
6. Manufacturing assembly Handbook:- BrunoLotter
7. Anatomy of Automation, Amber G.H & P. S. Amber, Prentice Hall.
8. Performance Modeling of Automated Manufacturing Systems, Viswanandham, PHI
9. NPTEL Video Lecture , Web: http://nptel.ac.in, Automation and control
10. Software available: Pneumatic and hydraulic simulation , CyberTech

PHDME – 104A

FLEXIBLE MANUFACTURING SYSTEM

PhD (Mechanical Engineering)

No. of Credits: 4		Sessional:	25 Marks
L | T | P | Total		Theory:	75 Marks
4 | 0 | 0 | 4		Total:	100 Marks
		Duration of Exam:	3 Hours

Course Objectives:

Course Outcomes: The research scholar shall be able to

CO1 Understand the concept of flexibility in manufacturing

CO2 Identify various workstations, system support equipment's of FMS.

CO3 Identify hardware and software components of FMS.

CO4 Apply the concepts of PPC and GT to the development of FMS.

CO5 Utilize the concepts of modern manufacturing such as JIT, supply chain management and lean manufacturing etc. in FMS.

Unit 1 **Introduction:** FMS definition and classification of manufacturing systems, Automated production cycle, Need of flexibility, Concept of flexibility, Types of flexibilities and its measurement.

Unit 2 **FMS Equipment:** Why FMS, Factors responsible for the growth of FMS, FMS types and applications, Economic justification for FMS, Functional requirements for FMS equipments, FMS processing and QA equipment, e.g., turning and machining centers, Co-ordinate measuring machines, Cleaning and deburring machines, FMS system support equipment, Automated material handling and storage equipment, cutting tool and tool management, Work holding considerations, Fixture considerations in FMS environment.

Unit 3 **Group Technology:** GT concepts, Advantages of GT, Part family formation-coding and classification systems; Partmachine group analysis, Methods for cell formation, Use of different algorithms, mathematical programming and graph theoretic model approach for part grouping, Cellular vs FMS production.

Unit 4 **FMS related problem and Solution Methodology:**

- FMS design problems: Part assignment, Machine selection, Storage system selection, Selection of pallets and fixtures, Selection of computer hardware and software, designing for layout integration of machine storage, Material handling System and computer system, Communication networks.
- FMS planning problems: Strategic planning, Part type selection, Machine grouping, production ratio and resource allocation, Machine loading problems.
- Operational & Control problems: Part scheduling, Machines robots & AGVS, Process monitoring & control.
- FMS Implementation: Objectives, acceptance testing, Performance goals and expectation maintenance concerns.

Reference Books:

1. Automation, Production System & Computer Integrated Manufacturing by Groover. Pub.: Englewood
2. Design and Operation of SMS by Rankey. Pub.: IFS
3. Flexible Manufacturing System by Wernecks. Pub.: Spring-Verlag
4. FMS in Practice by Bonctto. Pub.: Northox Ford
5. Flexible Manufacturing Cells and systems by W.W. Luggen Pub.: Prentice Hall India
6. Performance Modelling of Automated Manufacturing Systems by Vishwanathan & Narahari. Pub.: Prentice Hall India

PHDME – 105A

SUPPLY CHAIN MANAGEMENT

PhD (Mechanical Engineering)

No. of Credits: 4		Sessional:	25 Marks
L | T | P |Total		Theory:	75 Marks
4 | 0 | 0 | 4		Total:	100 Marks
		Duration of Exam:	3 Hours

Course Objectives:

- To understand the basic concept of SC as per industry perspective.
- To understand the concept of supplier, manufacturer and distributor in SC.
- To understand the concept of transportation and network design in supply chain.
- To understand the concept of ICT in supply chain.

Course Outcomes: The research scholar shall be able to

CO1 Integrate the supply chain process as per industry requirement.

CO2 Perform analysis on different issues of the Supply chain dynamics.

CO3 Analyze various issues related to SC performance.

CO4 Improve the efficiency and reduce cycle time/cost of production system by optimizing supply chain.

CO5 Implement ICT tools for SCM.

Unit 1 **Introduction:** Understanding supply chain, supply chain performance; supply chain drivers and obstacles.

Unit 2 **Planning Demand and Supply in a Supply Chain:** Demand forecasting in supply chain, aggregate planning in supply chain, planning supply and demand; managing predictable variability, economic order quantity models, reorder point models, multi-echelon inventory systems. Risk pooling, Value of Information, Bullwhip Effect.

Unit 3 **Planning and Integration in a Supply Chain:** Managing uncertainty in a supply chain, Supply chain Integration, Supplier relationship, VMI, Strategic Alliances, Procurement decisions.

Unit 4 **Distribution & Transportation, Network Design:** Distribution network design, Transportation aspects in a supply chain, facility decision, Warehousing decisions in a supply chain.

Unit 5 **Coordinating a Supply Chain and IT-enabled Supply Chains:** Coordination and e-business in a supply chain, Information technology and its use in supply chain. Technology Standards in a supply chain.

Reference Books:

1. Designing and Managing the Supply Chain (3rd ed.) by D. Simchi-Levi, P. Kaminsky, E. Simchi-Levi and Ravi Shankar. Pub.: Tata McGraw-Hill, 2008.
2. Supply Chain Logistics Management (2nd ed.) by Donald Bowersox, David Closs, M. Bixby Cooper. Pub.: Mcgraw Hill

PHDME – 106A

ENGINEERING FAILURE ANALYSIS AND PREVENTION

PhD (Mechanical Engineering)

No. of Credits: 4		Sessional:	25 Marks
L | T | P |Total		Theory:	75 Marks
4 | 0 | 0 | 4		Total:	100 Marks
		Duration of Exam:	3 Hours

Course Objectives:

The aim of this course is to provide knowledge on the procedures and mechanisms involved in failure analysis and prevention.

Course Outcomes: The research scholar shall be able to

CO1 Develop understanding of procedural approaches in creep failure analysis.

CO2 Understand fatigue failure mechanism.

CO3 Analyze various theories of failures and fracture mechanics.

CO4 Understand various surface treatment for failure prevention.

CO5 Implement ICT tools for SCM.

Unit-1

Introduction, Ductile fracture Brittle Fracture, Cleavage and intergranular fractures ,Impact fracture testing . Creep, Steady-state creep, Effects of stress and temperature on creep, Creep mechanisms, Linear-viscous creep, Power-law creep. ASTM standards for testing materials: tensile testing, fatigue testing, creep testing , etc.

Unit-2

Fatigue, the Wöhler curve, Fatigue probability curves, Crack initiation and crack propagation in fatigue, Environmental factors affecting fatigue, design against fatigue, Processing failures (Forging, Casting, Machining etc.), Fatigue failures in joints and weldments.

Unit-3

Fundamentals of fracture – definitions, Common causes of failure, Principles of failure analysis, Service failure mechanisms, Fracture modes, Fracture mechanics approach to failure problems, Techniques of failure analysis, Stress concentration, the Griffith criterion, Fracture toughness, wear failures, Fretting failures, Environmental induced failures.

Unit-4

Surface treatment for failure prevention, Heat treatment, Quenching, tempering, Shot peening, sand blasting, Coatings, Cladding, plating . Case studies for ferrous and non-ferrous metallic parts and parts made from polymers and ceramic for failure prevention.

Text Books:

1. Machine design- an integrated approach by R. L. Norton, Pearson Education, Asia.
2. Mechanical Metallurgy by George E. Dieter, Tata McGraw Hill Pub., New Delhi
3. Design of machine elements by V. B. Bhandari, Tata McGraw Hill Pub., New Delhi

Reference Books:

1) A.J. McEvily, J. Kasivitamnuay, Metal Failures: Mechanisms, Analysis, Prevention, Wiley-Interscience, 2013.
2) I. Milne, R.O. Ritchie, B.L. Karihaloo (Eds.), Comprehensive Structural Integrity, Elsevier, 2006.

NPTEL Video Lecture, Failure and Prevention, Web: http://nptel.ac.in/

PHDME – 107A

THERMOECONOMICS AND POWER PLANTS

PhD (Mechanical Engineering)

No. of Credits: 4		Sessional:	25 Marks
L | T | P |Total		Theory:	75 Marks
4 | 0 | 0 | 4		Total:	100 Marks
		Duration of Exam:	3 Hours

Course Objectives:

To be familiar with first law & second law of thermodynamics based analysis, energy auditing, various irreversibilities, thermo-economics and concept application to thermal systems and their design.

Course Outcomes: The research scholar shall be able to

CO1 Differentiate between the First law of thermodynamics and second law of thermodynamics.

CO2 Understand real and actual thermal cycles.

CO3 Understand the significance of exergy analysis.

CO4 Implement the thermo-economics/exergo-economics concepts to thermal systems.

CO5 Design the thermal systems from the thermo-economic/ exergo-economic point of view

Unit 1: First law optimization, availability, Exergy analysis, Second law optimization of thermal systems.

Unit 2: Energy audits and conservation programme, elements of energy accounting, Economic aspects of Power plants.

Unit 3: Economic analysis- principles of the economic evaluation, levelized cost.

Unit 4: Thermo- economic analysis: Fundamentals of thermo- economics, thermo- economic variables, thermo- economic evaluation, thermo- economic optimization.

Unit 5: Review of various ideal cycles- Rankine and Brayton- and fuel air cycles, Thermodynamic optimization of design parameters, Real cycle effects- internal and external irreversibilities, pressure drops, heat loss, combustion losses and their impact on thermodynamic cycle.

Unit 6: Coal based power plants, Performance analysis of components, steam power plants heat balance.

Reference Books:

1. Thermal Design & Optimization by Bejan.
2. Exergy method of Thermal Plant analysis by Kotas
3. Power Plant engineering by P.C. Sharma

PHDME – 108A

APPLIED COMPUTATIONAL METHODS

PhD (Mechanical Engineering)

No. of Credits: 4		Sessional:	25 Marks
L | T | P |Total		Theory:	75 Marks
4 | 0 | 0 | 4		Total:	100 Marks
		Duration of Exam:	3 Hours

Course Objectives:

- To understand essential concepts of Computational Mathematics.
- To learn about the concept of mathematical equations in different forms and different solving techniques.

Course Outcomes: The research scholar shall be able to

CO1 Understand the concept of Mathematical algorithms.

CO2 Learn about the methods of solving differential equations.

CO3 Learn about the solving of different methods of Algebraic equations.

CO4 Understand the concept of Matrix and Determents.

Unit 1 **Introduction:** Algorithms. Methods of undetermined coefficients. Numerical differentiation and integration.

Unit 2 **Differential and Algebraic Equations:** Solution of ordinary differential equations. Solution of linear and non-linear algebraic equations, Boundary value problems and initial value problems, Numerical solution of partial differential equations, Solution of polynomial and transcendental equations, ordinary differential equations with initial conditions.

Unit 3 **Matrix Algebra:** matrix algebra and simultaneous equations, eigen values and eigenvectors of a real symmetry matrix, least square curve fittings. Eigenvalue problems.

Reference Books:

1. Higher Engineering Mathematics by Dr. B.S. Grewal (Khanna Publishers)

PHDME – 109A

PLASTICS PROCESSING AND MOULD MANUFACTURING PROCESSES

PhD (Mechanical Engineering)

No. of Credits: 4		Sessional:	25 Marks
L | T | P |Total		Theory:	75 Marks
4 | 0 | 0 | 4		Total:	100 Marks
		Duration of Exam:	3 Hours

Course Objectives:

- To understand various aspects of plastics processing and mold manufacturing.
- To understand different computational methods used in mechanical engineering.

Course Outcomes: The research scholar shall be able to

CO1 Analyse and use various plastic processing methods.

CO2 Develop understanding of advance manufacturing processes.

CO3 Apply different computational methods used in mechanical engineering.

CO4 Use various optimization tools and software in research.

Unit 1 **Plastics Processing:** Plastics processing and classification of processing Machines; Injection Molding, Blow Molding, Extrusion, calendaring, thermoforming, various method of processing of FRP.

Unit 2 **Manufacturing:** Advanced Engineering Materials & the limitations of Conventional manufacturing processes; Classification of advanced manufacturing processes; Water jet & abrasive water jet machining; Ultrasonic machining; Electrical discharge machining; Ion Beam, Electron Beam & Laser beam in manufacturing; PVD & CVD; Micro and Nano Manufacturing.

Unit 3 *** Computational Methods in Mechanical Engineering:** Introduction to the computer hardware and the software; Numerical errors; Solving algebraic equations, Newton- Raphson method, systems of nonlinear equations; Curve fitting, Least square method; Numerical Integration, Trapezoidal rule; Solution of linear systems, direct and iterative methods; Numerical solution of ordinary differential equations, Runge-Kutta methods, shooting method; Numerical solution of partial differential

equations; Stability analysis. Application of various analysis / optimization tools /software's.

* (optional) Research Scholar must go though the various computational techniques as per requirement according to the Research area

Reference Books:

1. A Ghosh and A K Mallik, Manufacturing Science, Affiliated East-West Press Pvt Ltd, 1995.
2. James Brown, Modern Manufacturing Processes, Industrial Press Inc, 1991.
3. William M. Steen, Laser Material Processing, 3rd edition, Springer, 2003.
4. Mark J. Jackson, Microfabrication and Nanomanufacturing, Taylor & Francis, 2008.
5. Chue San Yoo, Semiconductor Manufacturing Technology, World Scientific, 2008.
6. S. S. Sastry, Introductory Methods of Numerical Analysis, 4th edition, Prentice Hall of India Private Limited, 2006.
7. S. V. Patankar, Numerical heat transfer and fluid flow, Taylor & Francis, 2007.

PHDME – 110A

ADVANCED MANUFACTURING SYSTEMS

PhD (Mechanical Engineering)

No. of Credits: 4		Sessional:	25 Marks
L | T | P |Total		Theory:	75 Marks
4 | 0 | 0 | 4		Total:	100 Marks
		Duration of Exam:	3 Hours

Course Objectives:

Course Outcomes: The research scholar shall be able to

CO1 Understand different manufacturing systems like NC, CNC, FMS, RMS, DMS etc.

CO2 Analyze the machining processes and evaluate the role of each process parameter during machining of various advanced materials.

CO3 Understand and use unconventional machining processes for manufacturing.

CO4 Apply the tools and techniques of quality to resolve manufacturing issues.

CO5 Apply Total Quality management principles in manufacturing.

Unit 1 **Manufacturing systems:** Introduction to manufacturing systems, fundamentals of numerical control (NC). Advantage of NC systems, Classifications of NC. Path generation, CNC Milling and CNC lathe, FMS, components of FMS, Applications, merits and demerits of FMS. RMS and its applications, Difference between FMS, RMS, DMS.

Unit 2 **Unconventional Machining Processes:** Abrasive jet machining, applications, Process Parameters. Ultrasonic machining: Principles, applications, analysis of process parameters. Electro chemical machining and grinding. Electric discharge machining: principles, selection of tools materials and dielectric fluid. Electron beam machining relative merits and demerits. Laser beam machining Principles and application.

Unit 3 **Quality:** Basic Concept, Quality Costs, Fitness for Use, Quality Characteristics, Parameters of Fitness for use, Definition of quality and its meaning and importance in industry, Control and Quality control, Quality Tasks, Quality functions, The system Concept, Quality systems, quality assurance and ISO 9000 quality system

standards, Quality costs concept, Quality cost categories, Examples of Quality cost studies, Securing the Cost figures, Pareto Analysis, Cost reduction Programs and economics of quality.

Unit 4 **Total Quality Management:** Basic Concept of TQM, QFD, FMEA, JIT systems, Pareto analysis, Cause and effect diagram, Scatter diagram, Run charts, Graph theory approach

Reference Books:

1. A Ghosh and A K Mallik, Manufacturing Science, Affiliated East-West Press Pvt Ltd, 1995.
2. Quality Management by Kanishka Bedi. Pub.: Oxford Press

PHDME – 111A

SYSTEMS RELIABILITY AND MAINTENANCE MANAGEMENT

PhD (Mechanical Engineering)

No. of Credits: 4		Sessional:	25 Marks
L | T | P |Total		Theory:	75 Marks
4 | 0 | 0 | 4		Total:	100 Marks
		Duration of Exam:	3 Hours

Course Objective:

- To develop ability in formulating suitable maintenance strategies to achieve reliable a manufacturing system;
- To equip you with essential system diagnosis techniques so that you can identify and take appropriate actions on error symptoms and causes of failures.

Course Outcomes: The research scholar shall be able to

CO1 Understand the relationship of key concepts in reliability engineering and application to maintenance strategies in a manufacturing environment

CO2 Establish maintenance strategies according to system characteristics and design transition programs to implement these strategies

CO3 Understand the concepts of RAM

CO4 Develop the mathematical modelling for stochastic processes

Unit 1 Introduction to reliability, availability and safety engineering and management. Select statistical concepts and probability distributions. Optimization techniques for systems reliability, availability and safety.

Unit 2 Maintenance Planning and Control. Maintenance management objectives and functions. Classification of Maintenance system. Diagnostic tools of failure analysis: Failure Mode Effect and Criticality Analysis, Fault Tree Analysis.

Unit 3 Information System for Reliability, Safety and Maintenance Management. Human factors in maintenance, Maintenance Manpower Planning.

Unit 4 System concepts in RAM Engineering, Failure distributions, Statistical analysis of failure data, System reliability assessment. Reliability of repairable and non-

repairable systems. Steady state availability. Availability assessment. Maintainability and its assessment. Design for reliability and maintainability', Practical applications of RAM Engineering to systems, products and processes.

Unit 5 Stochastic Processes: Definition and classification of general stochastic processes. Markov Chains: definition, transition probability matrices, Markov Chains with Discrete State Space: Poisson process, birth and death processes. Renewal Process: renewal equation, mean renewal time, stopping time.

Reference Books:

1. Reliability Engineering by BalaGuruswamy (TMH)
2. An Introduction to Stochastic Modeling, Fourth Edition by Mark A. Pinsky (Author), Samuel Karlin (Author) - Academic Press

PHDME – 112A

DESIGN OF CUTTING TOOLS

PhD (Mechanical Engineering)

No. of Credit: 4				Sessional:	25 Marks
L	T	P	Total	Theory:	75 Marks
4	0	0	4	Total:	100 Marks
				Duration of Exam:	3 Hours

Unit-1: Tool material and Coating: Advance cutting tool materials, properties and their applications, Types of coatings, coating methodology, coating materials and manufacturing equipments, coating inspection and testing, erosion of coating and their properties.

Unit-2: Design of Drills: Drilling machines, types of drills, elements of drill, drill wear, types of drill point sharpening, cutting forces in drilling, cutting conditions, counter boring, spot facing and counter sinking, design of drills for circular or round holes, design of drill for non-circular (especially square) holes/cavties.

Unit-3: Design of Reamers: Reaming action (mechanism), types of reamers, elements of reamer, wear and re-sharpening, cutting forces in reaming, cutting conditions, design of reamer.

Unit-4: Milling practice: Types of milling machines, method of milling, types of milling cutter, geometry of milling cutter, cutting forces in milling, cutting conditions, vibration in milling, milling cutters, design of form milling cutter.

Unit-5: Deep hole drilling and Trepanning: Gun drilling, gun boring, pressure coolant reamers, basic requirement of gun drilling and boring, quality of hole, trepanning, deep hole trepanning cutters.

Unit-6: Gear cutting practice: Methods of gear cutting, gear hobbing, gear shaping, gear shaving, hobbing cycle and hob design.

References:

1. Production Technology by HMT Bangalore

PHDME – 113A

COMPUTER AIDED MANUFACTURING SYSTEMS

PhD (Mechanical Engineering)

No. of Credits: 4		Sessional:	25 Marks
L | T | P |Total		Theory:	75 Marks
4 | 0 | 0 | 4		Total:	100 Marks
		Duration of Exam:	3 Hours

Course Objective:

- To understand the fundamentals of CAD/CAM, different concepts of Computer Aided Manufacturing like NC,CNC, Automated Material handling, FMS and CIM.
- To recognize the application of CAM concepts in different manufacturing systems.

Course Outcomes: The research scholar shall be able to

CO1 Implement the basic fundamentals of CAD/CAM.

CO2 Develop programming using CNC Part Programming.

CO3 Know about Automated Material handling & Flexible Manufacturing Systems.

CO4 Understand the applications of various CIM methodologies.

Unit 1. Introduction: CAD/ CAM defined, computer technology: introduction, central processing unit, types of memory, input/ output, the binary number system, computer programming languages. Role of CAD/CAM in improving the product cycle. Introduction to CIM. Applications of computers in CIM.

UNIT 2. Conventional Numerical Control: Introduction to numerical control, basic components of NC system, Problems with conventional NC, computer numerical control, direct numerical control, adaptive control machining systems

UNIT 3. NC part programming: NC coordinates and motion control systems, punched tape in NC, tape coding and format. Manual and computer assisted part programming, simple exercise in APT language.

UNIT 4. Automated material Handling and FMS: material handling function, types of material handling equipments, conveyor systems, types of conveyors, automated guided vehicle system, applications, FMS, components of a FMS, types of systems,

where to apply FMS technology, FMS workstation, planning the FMS. Introduction, components of FMS, application workstations.

UNIT 5. Computer Integrated Manufacturing systems: Introduction, Technologies used in CIM, Difference between CIM and FMS, CIM hierarchy system, Implementation process of CIM, applications and benefits of CIM.

Reference Books:

1. A Ghosh and A K Mallik, Manufacturing Science, Affiliated East-West Press Pvt Ltd, 1995.
2. Automation, Production Systems and Computer Integrated Manufacturing, M.P. Groover, Pearson Education.
3. Flexible Manufacturing System by Wernecks. Pub.: Spring-Verlag

PHDME – 114A

FINITE TIME THERMODYNAMICS AND THERMOECONOMICS OF THERMAL SYSTEMS

PhD (Mechanical Engineering)

No. of Credits: 4		Sessional:	25 Marks
L | T | P |Total		Theory:	75 Marks
4 | 0 | 0 | 4		Total:	100 Marks
		Duration of Exam:	3 Hours

Course Objectives:

To be familiar with first law & second law of thermodynamics based analysis, finite time thermodynamics, energy auditing, various irreversibilities, thermo-economics and concept application to thermal systems and their design.

Course Outcomes: The research scholar shall be able to

CO1 Differentiate between the First law of thermodynamics and second law of thermodynamics.

CO2 Understand FTT, real and actual thermal cycles.

CO3 Understand the significance of exergy analysis.

CO4 Implement the thermo-economics/exergo-economics concepts to thermal systems.

CO5 Design the thermal systems from the thermo-economic/ exergo-economic point of view.

Section A

Unit 1: First law optimization, availability, exergy analysis, second law optimization of thermal systems, Finite time thermodynamics and its applications to thermal systems.

Unit 2: Energy audits and conservation programme, elements of energy accounting. Economic analysis- principles of the economic evaluation, levelized cost.

Unit 3: Thermo- economic analysis: Fundamentals of thermo- economics, thermo- economic variables, thermo- economic evaluation, and thermo-economic optimization, Application of thermo economics to thermal systems.

Section B

(Power Plants)

Unit 4: Review of various ideal cycles- Rankine and Brayton- and fuel air cycles, Thermodynamic optimization of design parameters.

Unit 5: Real cycle effects- internal and external irreversibilities, pressure drops, heat loss, combustion losses and their impact on thermodynamic cycle.

Unit 6: Coal based power plants, Performance analysis of components, steam power plants heat balance, Gas power plants and cogeneration, Economic aspects of Power plants.

or

(Refrigeration and Air Conditioning)

Unit4: Thermodynamic basis, first & second law analyses of Vapour compression systems: Ideal and actual cycles; Single stage, multistage and cascade systems, Environmental aspects and alternate refrigerants.

Unit 5: Vapour absorption systems ; Single stage, multistage and open cycle systems, typical applications of refrigeration and cryogenics, Effect of Component efficiencies as performance, Simulation of performance of different liquefaction cycles, Cryogenic Refrigerators, Effect of irreversibilities on system performance.

Unit 6: Solar energy option, solar radiation, thermal energy storage, collectors and their performances, advanced collectors, solar refrigeration and air conditioning.

References:

1. Advanced Thermodynamics by Bejan
2. Thermal Design & Optimization by Bejan.
2. Exergy method of Thermal Plant analysis by Kotas
3. Power Plant engineering by P.C. Sharma
4. Refrigeration and Air conditioning by Arora and Domkundwar
5. Solar Refrigeration and Space Conditioning by S.C. Kaushik, Divyajyoti Prakashan
6. Solar Energy by S.P. Sukhatme, TMH.

PHDME – 115A

INTRODUCTION OF COMPUTATIONAL FLUID DYNAMICS AND APPLIED SUPERCONDUCTIVITY

PhD (Mechanical Engineering)

No. of Credits: 4		Sessional:	25 Marks
L | T | P |Total		Theory:	75 Marks
4 | 0 | 0 | 4		Total:	100 Marks
		Duration of Exam:	3 Hours

Course Objectives:

- To understand essential concepts of Computational Mathematics.
- To learn about the concept of mathematical equations in different forms and different solving techniques.
- To learn about the basic principles of Computational Fluid Dynamics.
- To learn about the basic principles of superconductivity and superconducting magnets.

Course Outcomes: The research scholar shall be able to

CO1 Understand the concept of Mathematical algorithms.

CO2 Learn about the methods of solving differential equations Matrix Algebra.

CO3 Learn about the Basics of Computational Fluid Dynamics.

CO4 Understand the concept of Superconductivity.

CO5 Understand the concept of Superconducting Magnets.

Unit 1 Introduction: Algorithms, Methods of Undetermined Coefficients. Numerical Differentiation and Integration. Solution of Ordinary Differential Equations. Solution of Linear and Non-linear Algebraic Equations, Boundary Value Problems and Initial Value Problems, Numerical Solution of Partial Differential Equations, Ordinary Differential Equations with Initial Conditions.

Unit 2 Matrix Algebra and Simultaneous Equations: Eigen Values and Eigenvectors of a Real Symmetry Matrix, Least Square Curve Fittings, Eigenvalue Problems.

Unit 3 Introduction to Computational Fluid Dynamics and Principles of Conservation: Continuity Equation, Navier Stokes Equation, Energy Equation and General

Structure of Conservation Equations, Classification of Partial Differential Equations and Physical Behaviour.

Unit 4 Approximate Solutions of Differential Equations: Error Minimization Principles, Variational Principles and Weighted Residual Approach, Fundamentals of Discretization: Finite Element Method, Finite Difference and Finite Volume Method.

Unit 5 Introduction of Superconductivity: Superconducting Magnet Winding Configuration; Solenoid Magnet; Force and Stress in Superconducting Magnet.

Unit 6 Quenching of Superconducting Magnets: Mechanical and Thermal Properties of Material of Superconducting Magnet; Application of Superconducting Magnets.

Reference books:

1. Martin N. Wilson, "Superconducting Magnets", Clarendon Press. Oxford; 1983.
2. Y. Iwasa, "Case studies in superconducting magnets", Plenum Press, New York and London, 1994.
3. D. Bruce Montgomery, "Solenoid Magnet Design. The Magnetic and Mechanical Aspects of Resistive and Superconducting Systems" Wiley-Interscience, New York, 1969.
4. Higher Engineering Mathematics by Dr. B.S. Grewal (Khanna Publishers).
5. Computational Fluid Dynamics The Basics with Applications by John D. Anderson

PHDME – 116A
DATA SCIENCE
PhD (Mechanical Engineering)

No. of Credits: 4		Sessional:	25 Marks
L | T | P |Total		Theory:	75 Marks
4 | 0 | 0 | 4		Total:	100 Marks
		Duration of Exam:	3 Hours

Unit 1 **Introduction:** Big Data overview, Characteristics, Big Data Analytics, Application of Big Data- in science, manufacturing, health care, Government, Education, Information Technology.

Unit 2 **Intro to Python:** Character Set, Basic Data Types- integer, float, list, strings. Operators, Data Flow Mechanism: Decision Statements, If Statements, if-else statements. Loop control Statements, for Loops, while.

Unit 3 **More Python:** Advance Python features: Functions, Syntax and use of a Function, Dictionaries- Creating, Formatting etc., and Operations in dictionary, Methods of Dictionary class. Files file handling, Text Input and Output, seek function, Binary Files.

Unit 4 **Mathematical Computing:** Knowledge on Packages like The numpy Library- numpy, ndarray, dtype, Intinsic creation of array, Indexing, Slicing, and Iterating.

Unit 5 **Pandas-** Introduction to pandas Data Structures, Data series, Data frame, Index object, Other Functionalities on Indexes, Function Application and Mapping, Data Preparation, Concatenating, Data Transformation, Discretization and Binning, String Manipulation, Data Aggregation, Group Iteration.

Unit 6 **Matplotlib-** The matplotlib Library, matplotlib Architecture, pyplot, using the kwargs, charts, Advance charts, mdplot3d, Multi-Panel Plots.

Unit 7 **Scipy-** File input/output, special function, Linear algebra operations, Interpolation, Optimization and fit, Statistics and random numbers, Numerical integration, Fast Fourier transformations, Signal processing, Image manipulation.

Unit 8 **Intro to machine Learning:** Setting up and working with Jupyter notebooks, importing, cleaning and assembling real-world data with the Pandas library. Displaying inline graphs and charts with Pandas and matplotlib, Sci-kit Learn.

Reference Books:

1. "Programming and Problem Solving with PYTHON" by Ashok Namdev Kamthane, McGraw Hill Education (India) Pvt. Ltd.
2. "Introduction to Computing and Problem Solving Using Python" by E Balagurusamy, McGraw Hill Education (India) Pvt. Ltd.
3. "Machine Learning in Python" by Raúl Garreta and Guillermo Moncecchi, PACKT Publishing BIRMINGHAM – MUMBAI.

PHDME – 117A

ADDITIVE MANUFACTURING

PhD (Mechanical Engineering)

No. of Credit: 4				Sessional:	25 Marks
L	T	P	Total	Theory:	75 Marks
4	0	0	4	Total:	100 Marks
				Duration of Exam:	3 Hours

Course Objectives:

The main objective of this course is to acquaint students with the concept of Additive Manufacturing (AM), various AM technologies, selection of materials for AM, modeling of AM processes, and their applications in various fields.

Course Outcomes: The research scholar shall be able to

CO1 Understand the concept of additive manufacturing and its applications.

CO2 Use different materials for additive manufacturing.

CO3 Learn various technologies in vogue for additive manufacturing.

CO4 Select correct process for additive manufacturing, its monitoring and control.

Unit-1: Introduction to Additive Manufacturing (AM): General overview, Introduction to reverse engineering, Traditional manufacturing vis AM, Computer aided design (CAD) and manufacturing (CAM) and AM, Different AM processes and relevant process

Application level: Direct processes - Rapid Prototyping, Rapid Tooling, Rapid Manufacturing; Indirect Processes - Indirect Prototyping, Indirect Tooling, Indirect Manufacturing.

Unit-2: Materials science for AM: Different materials used for AM, Use of multiple materials, multifunctional and graded materials in AM, Role of solidification rate, Evolution of non-equilibrium structure, Structure property relationship, Grain structure and microstructure.

Unit-3: AM Technologies: Powder-based AM processes involving sintering and melting (selective laser sintering, shaping, electron beam melting).

Printing processes: droplet based 3D printing; Solid-based AM processes - extrusion based fused deposition modeling, Stereolithography.

Unit-4: Process selection, planning and control for AM: Selection of AM technologies using decision methods; Additive manufacturing process plan: strategies and post processing. Monitoring and control of defects, transformation.

References:

1. Ian Gibson, David W. Rosen, Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing Springer, 2010.
2. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, 2011.
3. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: principles and applications, 3rd Edition, World Scientific, 2010.

PHDM-118A
WELDING, TESTING AND CHARACTERIZATION OF MATERIALS
Ph.D. (Mechanical Engineering)

No. of Credits: 4
L | T | P |Total
4 | 0 | 0 | 4

Sessional: 25 Marks
Theory: 75 Marks
Total: 100 Marks
Duration of Exam: 3 Hours

Course objective: The objective of the this course is to impart knowledge about the welding processes, weld testing and various characterisation techniques to the research scholar intended to work in the field of welding engineering.

Course Outcomes: After the completion of this course the student will be able to;

CO1: Understand the working of various welding power sources

CO2: Differentiate between welding processes, their principles and associated parameters

CO3: Apply the acquired knowledge in testing and inspection of welds

CO4: Prepare the specimen and analyse them using optical microscopy and other characterisation techniques

Syllabus:

1. Welding Power Sources

Conventional welding power sources; constructional features; static and dynamic characteristics; duty cycle; internal and external regulation; specific power source requirements; Special welding power sources. Friction stir welding setup.

2. Arc Welding Processes

Consumable electrode welding processes. Manual metal arc (MMA) welding; Gas metal arc welding; pulsed MIG welding; Submerged arc welding, Gas tungsten arc welding; Friction Stir welding; its parameters, applications, possible defects, Friction stir processing

3. Weldability, testing and Inspection of Welding

Weldability; definition, factor affecting the weldability of steel Carbon equivalent. Weldability of steel, cast iron and aluminium alloys of commercial importance.
Chemical tests; Metallographic tests; Hardness tests; Mechanical test for groove and fillet welds-full section, reduced section and all-weld- metal tensile tests, root, face and side bend tests, fillet weld break tests, creep & fatigue testing. Non-Destructive Testing of Weldments; Visual inspection; Dye-penetrant inspection; Magnetic particle inspection; Ultrasonic inspection principle of ultrasonic testing, Radiographic inspection –principle of radiography, X-ray tubes, gamma-ray sources, defect discernibility.

4. Optical metallography and other characterization methods

Working principle of Optical Microscope, components of microscopes, principles of phase contrast, elements of quantitative metallography and image processing, Sample preparation techniques for Optical metallography.

Production and properties of X-ray, diffraction methods. Working principles of diffractometer, counters and cameras. Indexing of XRD patterns. Precise lattice parameter determination, Chemical analysis by X-ray diffraction, Determination of particle size and micro/macro strains.
Scanning electron microscope; construction, interaction of electrons with matter, modes of operation, image formation of plane and fractured surfaces, sample preparation techniques.

References:

1. The Metallurgy of Welding, 6th Edition
2. Lancaster, William Andrew Publishing, NY.
3. Welding Hand Book Vol. 5; 7th edition, AWS, 1984.
4. Welding METALLURGY, S Kou, John Wiley, USA, 2003
5. Spencer, Michael, Fundamentals of Light Microscopy, Cambridge University Press,1982.
6. Joseph I Goldstein, Dale E Newbury, Patrick Echlin and David C Joy, "Scanning Electron Microscopy and X-Ray Microanalysis", 3rd Edition, 2005.
7. B.D.Cullity and S.R.Stock, "Elements of X-Ray Diffraction" Third edition, Prentice Hall, NJ, 2001.
8. Fundamentals of light microscopy and electronic imaging' Douglas B. Murphy, 2001, Wiley-Liss, Inc. USA

Weblinks:
https://nptel.ac.in/courses/112/107/112107089/
https://nptel.ac.in/courses/113/106/113106034/

PHDME-119A

ADVANCED METAL CASTING

PhD (Mechanical Engineering)

No. of Credit: 4				Sessional:	25 Marks
L	T	P	Total	Theory:	75 Marks
4	0	0	4	Total:	100 Marks
				Duration of Exam:	3 Hours

Course Objective:- The objective of this subject is to introduce the latest techniques in casting processes to the learner. The learner will able to understand the latest development/research in the field of manufacturing so that the complex and high grade quality products can be produced at lower cost.

Course Outcomes:-

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

1. Distinguish the different metals, melting furnaces and patterns used in foundry technology.
2. Describe the properties and testing of moulding sand and core.
3. Design the gating system.
4. Utilize various processes for improving or controlling the quality of cast product and environment of foundry shop.
5. Examine and analyze castings with various advanced analysis techniques.

Unit 1: Ferrous and Non-ferrous casting metals & their alloys and items made of them. Furnaces for cast iron, cast steels, aluminium and copper.

Pattern: Pattern material, Types of patterns, Pattern allowances, Colour coding system for patterns, Numerical on pattern allowances.

Unit 2: **Moulding:** Mould material, properties of moulding sand, Main constituents of moulding sand, Classification of moulding sand, Preparation of moulding sand, Testing of moulding sand.

Core: Introduction, Characteristics of core, Types of core, Core making, Core chaplets, Core print.

Unit 3: Gating system: Requirements of gating system, elements of gating system, Types of gates, Types of risers, Calculation of pouring time and solidification time, Casting design considerations, Chills.

Unit 4: Special casting methods: Investment casting, Shell mould casting, Evaporative pattern casting, EPS-Assisted Investment casting, Microwave casting, Freeze casting.

Unit 5: Fettling of castings, Heat treatment of castings, Quality control of castings, Modernization of foundry.

Unit-6: Casting inspection, Microstructure Analysis, X-ray diffraction (XRD), thermal gravimetric and differential thermal analysis (TGDTA) and wear performance by using scanning electron microscopy (SEM), Energy Dispersive X-Ray Analysis (EDX) etc.

Reference Books:

1. Principles of Metal Casting - Richard W. Heine , Carl R. Hoper, Philip C. Rosenthal, Tata McGraw Hill Education

2. Principles of Foundry Technology - P. L. Jain, Tata McGraw-Hill Education

3. Foundry practice - W.H. Salmon and E.N. Simons, Pitman

4. Principles of manufacturing materials and processes - J. S. Campbell, McGraw Hill

5. Materials and processes in manufacturing - E. Paul DeGarmo, J. T. Black, Ronald A. Kohser, John Wiley & Sons

6. A Textbook of Production Technology: Manufacturing Processes - P. C. Sharma, S. Chand publications