School of Engineering & Technology (Mechanical Engineering)

DIT University, Dehradun

DIT UNIVERSITY
IMAGINE ASPIRE ACHIEVE

Course Structure for Pre Ph.D. (ME) Course Work

Session: 2020-21

Approved by the Academic Council at its 14th Meeting held on 20.04.2020

Pre Ph.D. (Mechanical Engineering)

Course Category	Course Code	Course Title	L	T	P	Credit
UC	MB901	Research Methodology	4	0	0	4
-	CPE-RPE	Research Publication & Ethics	2	0	0	2
DE		Elective-I	4	0	0	4
DE		Elective-II	4	0	0	4
DE		Elective-III	4	0	0	4
DC	DS001	Seminar	0	0	2	1
		Total Credits				**19**

List of Elective Subjects (Thermal)

Sl.No.	Course Code	Name of Subject
1	ME941	Energy Efficient Buildings
2	ME942	Gas Turbines and Compressors
3	ME943	Design of Heat Exchangers
4	ME944	Solar Energy Systems
5	ME945	Computational Methods for Heat Transfer and Fluid Flow
6	ME946	Wind Energy Engineering
7	ME947	Fuel and Combustion Technology
8	ME948	I.C. Engines Combustion Process & Modeling
9	ME949	Energy Management, Audit and Conservation
10	ME951	Advanced Refrigeration and Air Conditioning
11	ME952	Convective Heat and Mass Transfer
12	ME953	Advanced Thermodynamics
13	ME954	Advanced Heat Transfer

List of Electives (Design and Manufacturing)

Sl.No.	Course Code	Name of Subject
1	ME961	Fracture and Failure Analysis
2	ME962	Mechanism Design
3	ME963	Advanced Mechanics of Solids
4	ME964	Computer Control and Machining Tools
5	ME965	Advanced Optimization Techniques
6	ME966	Composite Materials
7	ME967	Computer Aided Design and Graphics
8	ME968	Material Processing Techniques
9	ME969	Numerical Methods
10	ME971	Experimental Design & Analysis
11	ME972	Material Characterization
12	ME973	Advanced Manufacturing Techniques
13	ME974	Conventional Welding Processes
14	ME975	Inspection and Testing of weldments
15	ME976	Design of Experiments

Note : Apart from above listed Elective courses, Research Scholar may choose any course across departments being offered at PG level, if it is required/suggested by the Research Committee.

Pre Ph.D. (Mechanical Engineering)

Subject Code	**MB901**	**Subject Title**	**Research Methodology**						
LTP	4 0 0	**Credit**	4	**Subject Category**	UC	**Year**	1^{st}	**Semester**	I / II

UNIT – I

Fundamentals of Research: Defining research, Objectives of research, types, research process, deductive and inductive reasoning; Identifying and formulating a research problem, Literature review: Search for existing literature (World Wide Web, Online data bases), Review the literature selected (Case studies, review articles and Meta-analysis), Develop a theoretical and conceptual framework, Writing up the review.

Definition of variables: Concepts, indicators and variables, Types of variables, Types of measurement scales, Constructing the Hypothesis- Null(Research) and alternative, one-tailed and two-tailed testing, errors in testing. Ethical and Moral Issues in Research, Plagiarism, tools to avoid plagiarism – Intellectual Property Rights – Copy right laws – Patent rights

UNIT – II

Research Design: Design of Experiments: Research Designs -Exploratory, Descriptive and Experimental, Experimental designs- Types of Experimental Designs

UNIT – III

Sampling, Sampling distribution, and Data Collection: Sampling distribution, Normal and binomial distribution, Reasons for sampling, sampling technique, sampling errors. Sources of Data-Primary Data, Secondary Data, Data Collection methods

UNIT – IV

Statistical Data Analysis: Descriptive and inferential statistical analysis. Testing of hypothesis with Z-test, T-test and its variants, Chi-square test, ANOVA, Correlation, Regression Analysis, Introduction to data analysis data using SPSS20.0

UNIT – V

Research Report: Writing a research report**-** Developing an outline, Formats of Report writing, Key elements-Objective, Introduction, Design or Rationale of work, Experimental Methods, Procedures, Measurements, Results, Discussion, Conclusion, Referencing and various formats for reference writing of books and research papers, Writing a Research Proposal.

Books Recommended:

1. Ganesan R, Research Methodology for Engineers , MJP Publishers, Chennai. 2011
2. C.R.Kothari, “Research Methodology”, 5^{th} edition, New Age Publication,
3. Cooper, “Business Research Methods”, 9^{th} edition, Tata McGraw hills publication
4. Walpole R.A., Myers R.H., Myers S.L. and Ye, King: Probability & Statistics for Engineers and Scientists, Pearson Prentice Hall, Pearson Education, Inc. 2007.
5. Anderson B.H., Dursaton, and Poole M.: Thesis and assignment writing, Wiley Eastern 1997.
6. Bordens K.S. and Abbott, B.b.: Research Design and Methods, McGraw Hill, 2008.
7. Morris R Cohen: An Introduction to logic and Scientific Method (Allied Publishers) – P 197-222; 391–403

Pre Ph.D. (Mechanical Engineering)

Subject Code	ME941	Subject Title	Energy Efficient Buildings						
LTP	4 0 0	**Credit**	4	**Subject Category**	DE	**Year**	1st	**Semester**	I / II

Course objectives:

This course aims to provide an understanding of the concept of reduction in energy consumption through low energy building design. It will highlight strategies to integrate daylighting and low energy heating/cooling in buildings.

Syllabus

Unit I Architecture- Building Science and its significance.Indoor Environment.Components of Indoor Environment. Quality of Indoor Environment

Unit II Human Comfort-Thermal, Visual, Acoustical and Olfactory comfort. Concept of Sol-air temperature and its significance. Ventilation and is significance

Unit III Cooling and heating concepts, Passive concepts appropriate for the various climatic zones in India. Classification of building materials based on energy intensity.

Unit IV Energy Management of Buildings and Energy Audit of Buildings. - Energy management matrix monitoring and targeting.

Unit V Energy Efficient Landscape Design **-**Modification of microclimate through landscape elements for energy conservation.

Course outcomes:

On completion of this course, the students would:

- Have acquired an understanding of the concept and theoretical background of low energy building design.
- Be able to demonstrate their learning about use of simulation tools to achieve energy efficiency.

Reference Books:

1. SodhaM.,Bansal, N.K., Bansal,P.K., Kumar, A.. and Malik, M.A.S.,Solar Passive Buildings, Pergamon Press, 1986.
2. Koenigsberger, O.H., Ingersoll, T.G., Mayhew Alan and Szokolay, S. V., Manual of Tropical Housing and Building part 1: Climatic Design, OLBN 0 00212 0011,Orient Longman Limited, 1973.
3. Bureau of Indian Standards, I.S. 11907 –1986 Recommendations for calculation of Solar Radiation Buildings, 1986.
4. Givoni,B., Man, Climate and Architecture, Elsevier, Amsterdam, 1986.
5. Smith, R. J., Phillips, G.M. and Sweeney, M. Environmental Science, Longman Scientific and Technical, Essex, 1982.

Pre Ph.D. (Mechanical Engineering)

Subject Code	**ME942**	**Subject Title**	**Gas Turbines and Compressors**						
LTP	4 0 0	**Credit**	4	**Subject Category**	DE	**Year**	1^{st}	**Semester**	I / II

Course objectives:

To provide students with a thorough understanding of energy systems, heat transfer and thermodynamic applications to gas turbines and compressors. The student will be exposed to design and operation of compressors and turbines. In addition, the student will also learn about gas turbine cycles and modifications of gas turbine cycles.

Syllabus

Unit I **Gas Turbines**: Introduction, Thermodynamics of Axial Flow Turbine, Degree of Reaction, Preliminary Design Procedure for Turbine Stage.

Unit II Determination of Turbine Stage Efficiency, Axial Flow Turbine Performance, Compressor, Turbine Matching, Radial Inflow Gas Turbine, Thermodynamic Processes in Radial Inflow Gas Turbine.

Unit III **Centrifugal Fans Blowers and Compressors:** Classification Performance Parameters and Characteristics, Change of Performance, Polytropic Efficiency, Preliminary Design of Centrifugal Compressors.

Unit IV **Axial Flow Compressors:** Introduction. Basic Theory, Preliminary Design of Compressor Stage, Determination of Stage Efficiency, Axial Flow Compressor Performance, Surge and Stall in Compressor and the Remedies.

Unit V **Gas Turbine Power Plants**:Fuel and fuel feed systems; combustion systems-design considerations and flame stabilization; regenerator types and design; gas turbine power; plant performance and matching; applications.

Course outcomes:

The students will be able to:

- Analyse and design centrifugal compressor.
- Analyse and design axial flow compressors for various blade configurations.
- Analyse and design axial and radial flow gas turbine
- Design for matching of the components of gas turbine power plant.
- Analyse and evaluate gas turbine cycle performance.

Reference Books:

1. Ganesan, V., "Gas Turbines", Tata McGraw Hill, Publishing Company Ltd, Fourth Reprint, 2002.
2. Saravanamuttoo, HIH, Rogers, GFC, Cohen, H., "Gas Turbine Theory", Pearson Education Ltd, 5th Edition, 2001.
3. Yahya, S.M., "Turbines Compressors and Fans", Tata McGraw Hill, Publishing Company Ltd, Second Edition, 2002.

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Subject Code	**ME943**	**Subject Title**	**Design of Heat Exchangers**						
LTP	4 0 0	**Credit**	4	**Subject Category**	DE	**Year**	1st	**Semester**	I / II

Course objectives:
To impart knowledge of various types of heat exchangers, their construction and design, optimization criteria, performance behavior, and testing.

Syllabus

Unit I Classification of heat transfer equipment's, Specifications for heat exchangers, Standards of heat exchangers, design methodology, LMTD and NTU methods.

Unit II Design of double pipe heat exchanger-study and performance- Design of shell and tube heat exchanger.

Unit III Plate and spiral plate heat exchanger – plate heat exchanger for Dairy industry – Heat Pipes.

Unit IV Thermal design of heat exchange equipments such as Air pre-heaters, Economizer – Super heater and condensers.

Unit V Compact heat exchangers, Analysis and design of cooling towers.

Course outcomes:
At the end of the course students will have an idea about various design aspects and considerations about the equipment used for thermal power plants.

Reference Books:

1. Kern, D. Q., "Process Heat Transfer," McGraw-Hill Book Co., N.Y. 1997.
2. Shah,R.K. and Sekulic,D.P., "Fundamentals of Heat Exchanger Design", John Wiley and Sons Inc., 2003.
3. Kokac, S., "Heat Exchangers-Thermal Hydraulic Fundamentals and Design", McGraw Hill.
4. Gupta, J. P. , `Heat Exchanger Design A Practical Look', Delhi: C. S. Enterprises, 1979.
5. Lienhard, J.H. and Lienhard, J.H., "A Heat Transfer Textbook", Phlogiston Press, Cambridge, Massachusetts, 2005.

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Subject Code	**ME944**	**Subject Title**	**Solar Energy Systems**						
LTP	4 0 0	**Credit**	4	**Subject Category**	DE	**Year**	1st	**Semester**	I / II

Course objectives:
To introduce the fundamental concepts of solar energy and radiation measuring instruments. To impart knowledge of solar energy with respect to its availability, utilization, collection and storage. To educate about how to utilize solar energy to achieve the sustainable energy systems. To introduce various types of solar energy collecting devices and their performance analysis.

Syllabus
Unit I **Introduction:** Energy demand and supply, energy crisis, conventional and non-conventional energy resources, solar energy applications.
Solar Radiation: Sun, solar radiation, attenuation by atmosphere, solar radiation on earth, measurement, presentation and utilization of data.
Unit II **Heat Transfer Concepts:** Radiation characteristics of surface and bodies, absorbance, reflectance and transmittance, selective surface, sky radiation and wind convection.
Flat Plate Collectors: General description of flat plate collectors, general characteristics, performance, short term and long term performance, design.
Unit III **Focusing Collectors:** General description of focusing solar collectors, concentrators, receivers and orienting systems, general characteristics, performance, materials, design.
Energy Storage: Energy storage in solar process system, different types of storages, characteristics and capacity of storage medium, solar pond.
Unit IV **Solar Heating and Cooling:** Passive heating and cooling, nocturnal radiations, green house concept, ponds, active heating and cooling, solar water heaters, absorption cooling, combined solar heating and cooling systems, performance, economics of solar heating and cooling.
Unit V **Solar Process Modeling:** Solar process systems and components, component models, system models.
Solar Photovoltaics: Description and principle of working, performance characteristics, efficiency of solar cells, module design, PV systems, applications.

Course outcomes:
The students will be able to:
- Estimate the terrestrial solar radiation on an arbitrary tilted surface.
- Use flat plate solar collector mathematical model to calculate the efficiency and performance parameters of the same.
- Determine the useful gain and thermal efficiency of concentrating collectors.
- Explain the selection and installation of evacuated tube collector systems.
- Design and estimate the performance characteristics of solar photovoltaic system.

Reference Books:

1. ArturV.Kilian., “Solar Collectors: Energy Conservation, Design and Applications”, Nova Science Publishers Incorporated, 2009.
2. Soteris.A.Kalogiru., “Solar Energy Engineering: Processes and systems”, 1st edition, Academic press, 2009.
3. K.Sukhatme, SuhasP.Sukhatme., “Solar energy: Principles of thermal collection and storage”, Tata McGraw Hill publishing Co. Ltd, 8th edition, 2008.
4. Duffie, J. A. & W. A. Beckman., “Solar Engineering of Thermal Processes”, 3rd edition, John Wiley & Sons, Inc., 2006.
5. H.P.Garg, J.Prakash., “Solar energy fundamentals and applications”, Tata McGraw Hill publishing Co. Ltd, 2006.
6. D.YogiGoswami, Frank Kreith, Jan F.Kreider., “Principle of solar engineering”, 2nd edition, Taylor and Francis, 2nd edition, 2003.
7. G.N.Tiwari., “Solar energy: Fundamentals, Design, Modeling and Applications”, CRC Press Inc., 2002.

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Subject Code	**ME945**	**Subject Title**	**Computational Methods for Heat Transfer and Fluid Flow**						
LTP	4 0 0	**Credit**	4	**Subject Category**	DE	**Year**	1^{st}	**Semester**	I / II

Course objectives:
To impart the knowledge of computational methods in heat transfer and fluid flow, finite volume method, various techniques, boundary conditions.

Syllabus
Unit I Review of basic fluid mechanics and the governing (Navier-Stokes) equations. Types of partial differential equations- hyperbolic, parabolic and elliptic. Traditional solution methods- method of characteristics, separation of variables, Greens function method.

Unit II **Preliminary computational techniques:** Discretisation, converting derivatives to discrete algebric expressions, spatial derivatives, time derivatives. Approximation of derivatives, Taylor series expansion, general techniques. Accuracy of discretisation process-higher order vs lower order formulae.

Unit III **Finite difference method:** conceptual implementation, application to transient heat conduction problem. Convergence, consistency and stability of FD equation.

Unit IV **Weighted residual methods:** General formulation, Introduction to Finite Volume method, Equations with first derivatives and second derivatives. FV method applied to Laplace's equation.

Unit V **Finite Element method:** Linear interpolation, quadratic interpolation, two dimensional interpolations. Application to heat transfer problems.

Course outcome:
Students will be able to apply the computational methods to the heat transfer and fluid flow problems.

Reference Books:

1. Ferziger, J.H. and Peric, M.,"Computational Method for Fluif Dynamics", Springer-Verlag Berlin Heidelberg, 2002.
2. Anderson, J.D., "Computational Fluid Dynamics",McGraw-Hill Publication, 1995.
3. Murlidhar, K. and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publications, 2nd Edition, Reprint 2014.

Pre Ph.D. (Mechanical Engineering)

<table>
<tr><td>Subject Code</td><td>ME946</td><td>Subject Title</td><td colspan="7">Wind Energy Engineering</td></tr>
<tr><td>LTP</td><td>4 0 0</td><td>Credit</td><td>4</td><td>Subject Category</td><td>DE</td><td>Year</td><td>1st</td><td>Semester</td><td>I / II</td></tr>
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Course objectives:

The objective of this course is to present a broad overview of the technology covering aspects such as the history of wind turbine development, the characteristics of the wind and its impact on site selection, and the design, manufacture, and operation of modern wind turbines.

Syllabus

Unit I **Wind Energy Fundamentals**: Wind Energy Basics, Wind Speeds and scales, Terrain, Roughness, Wind Mechanics, Power Content, Class of wind turbines, Atmospheric Boundary Layers, Turbulence.

Unit II **Wind Measurements, Analysis and Energy Estimates**: Instrumentation for wind measurements, Wind data analysis, tabulation, Wind resource estimation, Betz's Limit, Turbulence Analysis, Aerodynamics Theory: Airfoil terminology, Blade element theory, Blade design, Rotor performance and dynamics, Balancing technique (Rotor & Blade), Types of loads; **Sources of loads.**

Unit III **Wind Turbines Technology &Components** : Wind turbines types:

Vertical Axis Type, Horizontal Axis, Constant Speed Constant Frequency, Variable speed Variable Frequency, Up Wind, Down Wind, Stall Control , Pitch Control, Gear Coupled Generator type, Direct Generator Drive ,PMG,Rotor Excited Sync Generator

Unit IV **Wind Turbine Control & Monitoring System**: Details of Pitch System & Control Algorithms, Protections used & Safety Consideration in Wind turbines, Wind Turbine Monitoring with Error codes, SCADA & Databases

Unit V **Concept of Wind Farms and project cycle**: Project planning, Site selection, Project execution, Operation and maintenance. Environmental concerns & Cost Economics

Course outcomes:

On completion of this module the student will:

- be capable of conducting a basic wind resource estimation and site assessment.
- understand the fundamentals of wind turbine design and operation
- understand issues related to integrating wind energy into an electricity distribution network
- appreciate the strengths and limitations of wind energy in an economic and political context

Reference Books:

1. Wind energy Handbook, Edited by T. Burton, D. Sharpe, N. Jenkins and E. Bossanyi, John Wiley & Sons, 2001
2. Wind and Solar Power Systems, Mukund. R. Patel, 2nd Edition, Taylor & Francis, 2001.
3. L .L. Freris, Wind Energy Conversion Systems, Prentice Hall, 1990.
4. D. A. Spera, Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, ASME Press.
5. Anna Mani &Nooley, "Wind Energy Data for India", 1983.

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Subject Code	**ME947**	**Subject Title**	**Fuel and Combustion Technology**						
LTP	4 0 0	**Credit**	4	**Subject Category**	DE	**Year**	1^{st}	**Semester**	I / II

Course objectives:
The learner will be exposed to various types of fuels, properties, processing and applications. In addition, the learner will be exposed to combustion stoichiometry and thermodynamics, combustion related pollution and control techniques.

Syllabus
Unit I **Fuels & Fuel Analysis**: Combustion Stoichiometry, theoretical & actual combustion processes, Air fuel ratio.

Unit II **Combustion Thermodynamics** calculation of heat of formation & heat of combustion – First law analysis of reacting systems.

Unit III **Heat Treatment Furnaces**: Industrial furnaces – process furnaces – Kilns – Batch & continuous furnaces.

Unit IV Flame**, Flame Structure, Ignition and Igniters**: flame propagation – deflagration – detonations- flame front – Ignition – self & forced ignition – Ignition temperature.

Unit V **Combustion Appliances:** Gas burners- Functional requirement of burners – Gas burner Classification – Stoker firing –pulverized system of firing.

Course outcomes:
The students will be able to:
- determine and analyse proximate and physical properties of a given fuel sample.
- determine and analyse heat balance sheet in a boiler.
- understand the processes in furnace.
- analyse flue gas samples and determine combustion stoichiometry.
- determine and analyse properties of liquid and gases fuels.

Reference Books:

1. Turns, S.R., An Introduction to Combustion - Concepts and Applications, 2nd ed., McGraw- Hill, 2000.
2. Sharma, S.P. and Mohan, C., Fuels and Combustion, Tata McGraw-Hill, 1987.
3. Sarkar. S., Fuels and Combustion, Orient Longman, 2005.
4. Combustion Fundamentals ,Roger A strehlow , Mc Graw Hill
5. Combustion Engineering and Fuel Technology ,Shaha A.K., Oxford and IBH.
6. Principles of Combustion ,KannethK.Kuo, Wiley and Sons.
7. An Introduction to Combustion , Stephen R. Turns, Mc. Graw Hill International Edition.
8. Combustion Engineering , Gary L. Berman & Kenneth W. Ragland, Mc. Graw Hill International Edition.

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Subject Code	**ME948**	**Subject Title**	**I.C. Engines Combustion Process & Modeling**						
LTP	4 0 0	**Credit**	4	**Subject Category**	DE	**Year**	1st	**Semester**	I / II

Course objectives:

The course is intended to expose the students to the most widely used mathematical models for in-cylinder spray and combustion processes.

Syllabus

Unit I Combustion process in CI and SI engines, flame structure and speed, spray structure.

Unit II Engine combustion modeling-overview, Modeling of flame propagation and heat release, burning speed, flame propagation relation.

Unit III Knock fundamentals, auto ignition, knock models.

Unit IV Modeling spray, spray equation, droplet kinematics, fuel vaporization.

Unit V Modeling pollutant and soot formation in engines.

Course outcomes:

The students will be able to:

- analyse the combustion process and determine the flame speed.
- model the flame propagation.
- model spray.
- model pollutant.

Reference Books:

1. V.Ganesan, Computer Simulation of Spark Ignition Engine Processes, Universities Press, 1995.
2. Ashley S. Campbell, Thermodynamic Analysis of Combustion Engines, John Wiley and Sons, 1980.
3. V.Ganesan, Computer Simulation of Compression Ignition Engine Processes, Universities Press, 2002.
4. Gordon P. Blair, The Basic Design of two-Stroke engines, SAE Publications, 1990.
5. Horlock and Winterbone, The Thermodynamics and Gas Dynamics of Internal Combustion Engines, Vol. I & II, Clarendon Press, 1986.
6. J.I.Ramos, Internal Combustion Engine Modeling, Hemisphere Publishing Corporation, 1989.
7. J.N.Mattavi and C.A.Amann, Combustion Modeling in Reciprocating Engines, Plenum Press, 1980.

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Subject Code	**ME949**	**Subject Title**	**Energy Management, Audit and Conservation**						
LTP	4 0 0	**Credit**	4	**Subject Category**	DE	**Year**	1st	**Semester**	I / II

Course objectives:
To impart basic knowledge to the students about current energy scenario, energy conservation, audit and management.To inculcate among the students systematic knowledge and skill about assessing the energy efficiency, energy auditing and energy management.

Syllabus
Unit I **Energy Scenario** - Basics of Energy and its various forms , Energy Management and Audit , Material and Energy Balance , Energy Action Planning, Financial Management , Project Management , Energy Monitoring and Targeting , Global Environmental Concerns.

Unit II **Energy Audit -**various Energy Conservation Measures in Steam -Losses in Boiler.Energy Conservation in Steam Systems, Case studies.

Unit III **Energy conservation-** Centrifugal pumps, Fans & Blowers, Air compressor – energy consumption & energy saving potentials – Design consideration.

Unit IV **Refrigeration & Air conditioning** - Heat load estimation -Energy conservation in cooling towers & spray ponds – Case studies Electrical Energy -Energy Efficiency in Lighting – Case studies.

Unit V Organizational background desired for energy management motivation, detailed process of M&T-Thermostats, Boiler controls- proportional, differential and integral control, optimizers; compensators.

Course outcomes:
Students will be able to :
- apply the knowledge of the subject to calculate the efficiency of various thermal utilities.
- design suitable energy monitoring system to analyse and optimize the energy consumption in an organization.
- improve the thermal efficiency by designing suitable systems for heat recovery and co-generation.
- use the energy audit methods learnt to identify the areas deserving tighter control to save energy expenditure.
- carry out the cost- benefit analysis of various investment alternatives for meeting the energy needs of the organization.

Reference Books:

1. Eastop T.D & Croft D.R, Energy Efficiency for Engineers and Technologists.
2. Logman Scientific & Technical, ISBN-0-582-03184, 1990.
3. Reay D.A, Industrial Energy Conservation, 1stedition, Pergamon Press, 1977.
4. Larry C Whitetal, Industrial Energy Management & Utilization.
5. Power System Engineering 2nd Ed. D P Kothari, I J Nagrath, Tata McGraw-Hill Co 2008.

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Subject Code	ME951	Subject Title	Advanced Refrigeration and Air Conditioning						
LTP	4 0 0	**Credit**	4	**Subject Category**	DE	**Year**	1st	**Semester**	I / II

Course objectives:
To teach the students about the methods of Refrigeration and its types, psychrometry and its principles.Teaching the cycle analysis pertaining to various Refrigeration systems, Air-conditioning systems, cooling load calculations.

Syllabus
Unit I Actual vapor compression system. MultipressureSystems , Cascade Systems-Analysis, Compressor- Types , performance , Characteristics of Reciprocating Compressors, Capacity Control , Types of Evaporators & Condensers and their functional aspects ,Expansion Devices and their Behavior with fluctuating load.

Unit II Vapor Absorption Systems-Aqua Ammonia &LiBr Systems, Steam Jet Refrigeration Thermo Electric Refrigeration, Air Refrigeration cycles.

Unit III Psychrometry: Moist Air properties , use of Psychrometric Chart , Various Psychrometric processes, Air Washer , Adiabatic Saturation. Summer and winter air conditioning: Air conditioning processes-RSHF , summer Air conditioning , Winter Air conditioning Bypass Factor. Applications with specified ventilation air quantity- Use of ERSHF, Application with low latent heat loads and high latent heat loads.

Unit IV Load estimation & air conditioning control: Solar radiation-heat gain through glasses , heat transfer through walls and roofs-Total cooling load estimation. Controls of temperature , humidity and air flow.

Unit V Air distribution: Flow through ducts , static & dynamic losses , air outlets , duct design–equal Friction method , duct balancing , indoor air quality , thermal insulation , fans & Duct system characteristics, fan arrangement variable air volume systems.

Course outcomes:
The students will be able to:
- Analyse, evaluate, and compare the performances of multipressure vapor compression systems.
- Perform thermodynamic analysis of absorption refrigeration systems and steam jet refrigeration system.
- Evaluate the various sources of heat load on buildings and perform a heat load estimate.
- Design summer and winter air conditioning systems.
- Design ducts for central air condition systems.

Reference Books:

1. Arora C.P., Refrigeration and Air Conditioning , Tata McGraw Hill Pub. Company , New Delhi - 2000.
2. Carrier Air Conditioning Co., Handbook of Air Conditioning Systems design, McGraw Hill , 1985.
3. Langley , Billy C. Refrigeration and Air Conditioning Ed. 3 , Engie wood Cliffs (N.J) Prentice Hall 1986.
4. ASHRAE , Fundamentals and equipment , 4 volumes-ASHRAE Inc. 2005.
5. Jones , Air Conditioning Engineering , Edward Amold pub. 2001.
6. Stoecker W.F., Refrigeration and Air conditioning , McGraw-Hill Book Company , 1989.
7. Jordan and Priester , Refrigeration and Air conditioning 1985.
8. Goshnay W.B., Principles and Refrigeration , Cambridge , University Press , 1985.

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Subject Code	ME952	Subject Title	Convective Heat and Mass Transfer						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1^{st}	Semester	I / II

Course objectives:

To impart knowledge of governing equations and solution techniques of the convective heat and mass transfer.

Syllabus

Unit I **Introduction**: Reynolds Transport Theorem; Compressible and Incompressible Flows; Conservation equations; Preliminaries on the Tensor Analysis; Dimensionless Numbers; Concepts of velocity boundary layer and thermal boundary layer, displacement thickness, momentum thickness and energy thickness; velocity boundary layer and thermal boundary layer equations.

Unit II **External Laminar Flows:**Laminar boundary layer flow over a Flat Plate; Similarity and integral solutions. Viscous dissipation effects on flow over a flat plate.
External Turbulent Flows: Analogy solutions for boundary layer flows – Integral equation solutions – Effects of dissipation on flow over a flat plate.Analysis of Heat Transfer and Flow over Circular Cylinders and spheres.

Unit III **Internal Laminar Flows**: Analysis of Heat transfer in laminar developed and developing duct flows. Turbulent Flow and Heat transfer through a pipe; Chilton-Colburn Analogy, Reynolds' Analogy; Convection Correlations.

Unit IV **Natural Convection**:Boussineq approximation – Governing equations – Similarity – Boundary layer equations for free convective laminar flows – Numerical solution of boundary layer equations. Free Convective flows through a vertical channel across a rectangular enclosure – Horizontal enclosure – Turbulent natural convection.

Unit V **Condensation:**Nusselts theory of film condensation on a vertical plate-assumptions and correlations of film condensation for different geometries.
Boiling: Nucleation and Bubble Growth; pool boiling; Flow boiling; Correlations.
Convective Mass Transfer: Concentration boundary layer – Momentum, mass and heat transfer analogy – Convective mass transfer numbers – Flow over flat plates, flow through tubes – Correlations – Evaporation of water into air – Heat and mass transfer in separated flows.

Course outcomes:
The students will be able to:

- Analyse and solve the single phase natural and forced convection problems.
- Analyse and solve the problems related to phase change processes.

Reference Books:

1. Patrick H. Oosthuigen& David Naylor, Introduction to Convective Heat Transfer Analysis, McGraw Hill, 1999.
2. W. M. Kays and E. M. Crawford, Convective Heat and Mass Transfer, Mc Graw Hill, 1993.
3. Louis C Burmeister, Convective Heat Transfer, John Wiley and Sons, 1993.
4. Adrian Bejan, Convective Heat Transfer, John Wiley and Sons, 1995.

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Subject Code	ME953	Subject Title	Advanced Thermodynamics						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1st	Semester	I / II

Course objectives:

The course aims to enrich the knowledge of students in thermodynamics. To predict the availability and irreversibility associated with the thermodynamic processes. To analyze the properties of ideal and real gas mixtures, behavior of pure substances and to understand the basic concepts of combustion, flame propagation and types of flames.

Syllabus

Unit I: **Review of Basics:** First law and Second law of thermodynamics, entropy generation, irreversibility and availability, exergy analysis and second law efficiency.

Unit II **Thermodynamic Relations:** Maxwell's relations, T-ds equations, specific heat relations, energy equations, Joule Thomson coefficient, ClausiusClaperyon Equation, Evaluation of Thermodynamic Properties.

Unit III **Non-Reactive Gas Mixtures :** Introduction, basic definitions for gas mixtures, PVT relationship for mixtures of ideal gases, properties of mixtures of ideal gases, entropy change due to mixing, mixtures of perfect gases at different initial pressure and temperatures.

Unit IV **Reactive Gas Mixtures:** Introduction, fuels and combustion, theoretical and actual combustion processes, enthalpy of formation and enthalpy of reaction, first and second law analysis of reacting systems.

Unit V **Thermodynamic cycles:** Vapor power cycles, second law analysis of vapor power cycles, cogeneration, binary vapor cycles, combined gas vapor power cycles, second law analysis of gas power cycles.

Course Outcomes:

Students will get an enriched knowledge about the availability and irreversibility associated with the thermodynamic processes, properties of ideal and real gas mixtures, and behavior of pure substances. The basic concepts of combustion, flame propagation, and types of flames will also be known.

Reference Books:

1. P.K. Nag, Engineering Thermodynamics **-** Tata McGraw-Hill Publications.
2. G. Van Wylen and R.E. Sonntag, Fundamentals of Classical Thermodynamics **-** Wiley, 1989.
3. YunusCengel& Boles, Thermodynamics (An Engineering Approach), TMH.
4. Michel A Saad ,Thermodynamics for Engineers, Prentice- Hall of India Pvt. Ltd. 1972.
5. J.P. Holman., Thermodynamics, 4th Ed., McGraw Hill, 1988.
6. Francis W, sears and Gerhard L. Salinger, Thermodynamics kinetic Theory and statistical thermodynamics Addison Wesley Publishing Co. 3ed Ed. 1975.
7. Francis W, sears Addison, Thermodynamics Kinetic Theory and Statistical. Mechanics Wiley Publishing Co. 1953.
8. J. Hsieg, Principles of Thermodynamics, McGraw Hill, 1978.
9. K. Wark, Advanced Thermodynamics for Engineers, McGraw Hill, NY, 1987.
10. K. Wark, Advanced Thermodynamics for Engineers, McGraw Hill, NY, 1987.

Pre Ph.D. (Mechanical Engineering)

Subject Code	ME954	Subject Title	Advanced Heat Transfer						
LTP	4 0 0	**Credit**	4	**Subject Category**	DE	**Year**	1st	**Semester**	I / II

Course Objectives:

- To enable the students apply the fundamentals of heat transfer modes such as conduction, convection, and radiation in various heat transfer applications.
- To enable the students apply analytical and semi analytical approach towards the solution of Heat Transfer problems.
- To prepare the students more competitive for thermal design of process equipment.

Syllabus

Unit I**Heat Conduction**: Fourier's law, thermal conductivity of matter, heat diffusion equation for isotropic and anisotropic media, boundary and initial conditions; One-dimensional steady-state conduction through plane wall, cylinder and sphere, conduction with thermal energy generation, heat transfer from extended surfaces, radial fins and fin optimization; Transient conduction – lumped capacitance method and its validity, plane wall and radial systems with convection, semi-infinite solid.

Unit II**Heat Convection**: Boundary layers concepts, laminar and turbulent flows, conservation equation, non-dimensional analysis, boundary layer equations, Reynolds analogy for turbulent flows; Forced convection inside tubes and ducts – correlations for laminar and turbulent forces convection; Forced convection over exterior surfaces – bluff bodies, packed beds, tube bundles in cross flow; Natural convection; Combined free and forced convection; Combined convection and radiation.

Unit III **Heat Transfer with Phase Change**: Nucleate, film and pool boiling, boiling in forced convection; Filmwise and dropwise condensation

Unit IV**Thermal Radiation:** Fundamental concepts, radiation intensity and its relation to emission, irradiation and radiosity, blackbody radiation, surface emission, surface absorption, reflection, and transmission, gray surface; Radiation exchange between surfaces, view factor, blackbody radiation exchange, radiation exchange between diffuse gray surfaces in an enclosure with absorbing and emitting media; Flame Radiation, solar Radiation.

Unit V**Numerical Methods in Heat Transfer:** Finite difference method for numerical simulation of steady state and transient heat transfer problems.

Course Outcomes:

At the end of the course the learners will be able to understand the subject of Heat Transfer in detail with capability to solve Industrial Problems. This will also create the base and interest among the students to carry out the Future Research.

Reference Books:

1. J.P. Holman., 'Heat and Mass Transfer', Tata McGraw Hill, 8th Ed., 1989.
2. Heat Transfer – A Basic Approach - Ozisik M.N., McGraw-Hill Publications, 1985.
3. Principles of Heat Transfer - Frank Kreith& M. S. Bohn, Thomson Publications, 2001.
4. F.P. Incropera and D. P. Dewit, Fundamentals of Heat and Mass Transfer', 4th Ed. John Wiley & Sons (Asia) Pte Ltd, 2002.
5. E.R.D Eckert and R.M. Drake, Analysis of Heat and Mass Transfer, McGraw Hill, 1980.
6. Kays, W.M. and Crawford W., Convective Heat and Mass Transfer', McGraw Hill Inc., 1993.

Pre Ph.D. (Mechanical Engineering)

Subject Code	**ME961**	**Subject Title**	**Fracture and Failure Analysis**						
LTP	4 0 0	**Credit**	**4**	**Subject Category**	DE	**Year**	1^{st}	**Semester**	I / II

COURSE OBJECTIVES:

This course provides an introduction to the students to have an overview of Fracture and failure analysis for design of various machine components. Student will also learn to appreciate nature and applicability of welding forging, wear and corrosion failure based on tests and safety considerations.

Unit 1: Sources of failures

Deficiencies in design, Material, Processing, Service and maintenance.Stages of failure analysis, Classification and identification of various types of fracture - overview of fracture mechanics concepts, Ductile and brittle fracture, Fracture origin, Initiators, Characteristics of ductile and brittle fracture.

Unit 2: Fatigue and creep failures

General concepts, Fracture characteristics revealed by microscopy, Factors affecting fatigue life some case studies of fatigue failures. Creep, Stress rupture, Elevated temperature fatigue, Metallurgical instabilities, Environmental induced failure.

Unit 3: Wear and corrosion failures

Types of wear, Role of friction in wear, lubricated and non-lubricated wear, analyzing wear failure. Corrosion failures- factors influencing corrosion failures, Analysis of corrosion failures, Overview of various types of corrosion stress corrosion cracking, Sources, Characteristics of stress corrosion cracking. Procedure for analyzing stress corrosion cracking, Various types of hydrogen damage failures.

Unit-4: Failure of Forging, Casting and Weldments

Causes of failure in forging like material characteristics, Deficiencies in design, Improper processing / fabrication or deterioration resulting from service conditions, Failure of iron and steel castings, Effect of surface discontinuities, Internal discontinuities, Microstructure, Improper composition, Improper heat treatment, Stress concentration and service conditions. Failure of weldments - reasons for failure procedure for weld failure analysis

Unit- 5: Fracture mechanics

Griffith (energy-based) fracture criterion, Energy release rate in linear and nonlinear elastic materials, Stability of crack growth in brittle materials, Microscopic fracture mechanisms, Charpy impact test, Ductile-to-brittle transition temperature phenomenon, Introduction to linear elastic fracture mechanics, Crack tip stress, Strain and displacement fields in linear elastic materials (modes i, ii and iii), The stress-intensity factor, k, Irwin's fracture criterion, Design philosophy using kic - specific examples, Stress intensity factors for important geometries, Methods for finding k.

COURSE OUTCOMES:

After completing this course, the students can :

- get the information of various types of failure happening in real engineering environment.
- get the knowledge about fatigue and creep failure.
- understand the various mechanisms of fracture and failure.
- aware of various failure like due to forging, corrosion, and in welding process.

Pre Ph.D. (Mechanical Engineering)

REFERENCE BOOKS:

1. Shipley, R. S. and Becker, W. T., ASM Metals Handbook, Failure Analysis and Prevention, ASM Metals Park (2002).
2. Colangelo, V. J. and Heiser, F. A., Analysis of Metallurgical Failures, John Wiley and Sons (1987).
3. Brooks, C. R. and Choudhury, A., Metallurgical Failure Analysis, McGraw Hill (1992).
4. Das, A. K., Metallurgy of Failure Analysis, McGraw Hill (1997).

Pre Ph.D. (Mechanical Engineering)

Subject Code	ME962	Subject Title	Mechanism Design						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1^{st}	Semester	I / II

COURSE OBJECTIVES:

Study of Kinematics of various mechanisms, Synthesis of linkages, graphical constructions of acceleration analysis, Static and dynamic force analysis of linkages, Synthesis of spatial mechanisms.

Unit 1: Introduction to Kinematic Motion and Mechanisms.

The four bar Linkage, The science of Relative motion, Kinematic diagrams, Six-bar chains, Degrees of freedom, Analysis vs. Synthesis.

Unit 2: Mechanism Design Philosophy

Stages of design, The synthesis process, Design categories and mechanism performance parameters.

Unit 3: Mechanism Analysis

Displacement velocity and acceleration analysis. Kinematic Synthesis of Mechanisms: Type, Dimensional, Number synthesis-The associated linkage concept. Graphical methods, Tools and computer programming for synthesis of mechanisms for two, three and four prescribed positions, Path generation, Prescribed and un-prescribed timings.Analytical Synthesis Techniques. Function and motion generation. Number of prescribed positions vs. Number of Free Choices.Extension of Three-precision-Point Synthesis to Multi-loop mechanisms.

Unit-4: Dynamics of Mechanisms

Inertia forces, Kineto-static Analysis by complex numbers, Superposition method, Matrix Method. Time response, Modification of time response of mechanisms.Virtual work. Lagrange Equations of motion.

Unit- 5: Spatial Mechanisms

Review of transformations for spatial mechanisms, Analysis of spatial mechanisms. Link and Joint Modeling with Elementary Matrices, Kinematic analysis of an Industrial Robot, Position, Velocity and Acceleration analysis.

COURSE OUTCOMES:

After completing this course, the students can :

- Get the knowledge about kinematics of various mechanisms.
- Get the knowledge about various mechanism analysis and its philosophy.
- get the knowledge about mechanism in dynamics and spatial environment

REFERENCE BOOKS

1. Sandor and Erdman, A.G., Mechanism Design (Analysis and Synthesis), Prentice Hall of India (1984).
2. Sandor and Erdman, A.G., Advanced Mechanism Design (Analysis and Synthesis), Prentice Hall of India (1984).
3. Shigley, J. E. and Uicker, J. J., Theory of Machines and Mechanisms, McGraw Hill (1995).
4. Beyer, R. A., Kinematic Synthesis of Mechanisms, McGraw Hill (1963).
5. Cowie, A., Kinematics and Design of Mechanisms, International Textbook (1961).
6. Hall, A. S. (Jr.), Kinematics and Linkage Design, Prentice Hall of India (1964).
7. Hartenberg, R. and Denavit, J., Kinematic Synthesis of Linkages, McGraw Hill (1964).

Pre Ph.D. (Mechanical Engineering)

Subject Code	**ME963**	**Subject Title**	**Advanced Mechanics of Solids**						
LTP	4 0 0	**Credit**	**4**	**Subject Category**	DE	**Year**	1st	**Semester**	I / II

Course objectives:
The primary objective of this course is to understand the structural responses to various loading conditions. The course provides the advance treatment of structures (e.g., curved beams) and loading conditions (e.g., unsymmetric bending).

Syllabus
Unit I**Three-Dimensional Stress Analysis:** Stresses on an arbitrary plane, Principal stresses and stress invariant, Mohr's stress circles, Differential equations of equilibrium in Cartesian and cylindrical coordinates, Three-dimensional strain analysis, Rectangular strain components, Principal strains and strain invariant, Compatibility conditions. Stress-Strain Relations: Generalized Hooke's law, Stress-strain relations for isotropic materials.

Unit II**Unsymmetrical Bending:** Flexure formula for unsymmetrical bending, Shear centre and its determination for various sections.
Curved Flexural Members: Winkler-Bach formula, Stresses in curved beams having rectangular, Circular and trapezoidal sections, Stresses in rings and chain links.
Unit III**Torsion of Non-circular Members:** Torsion of prismatic bars, Elastic membrane analogy, Torsion of sections composed of narrow rectangles
Unit IV **Thick Cylinders and Rotating Discs:** Lame's theory for stresses in thick cylinders, Composite tubes, Shrink fits and Laminated cylinders, Thin rotating rings, Stresses in rotating discs and cylinders, Discs of uniform strength.
Unit V **Energy Methods:** Principle of superposition, Work done by forces- elastic strain energy stored, Maxwell-Betti's theorem, Castigliano's theorems, Strain energy expressions, Fictious load method, Statically indeterminate problems.

Course outcomes:
- Able to apply concepts of stress, displacement and transformations to 3D solids under load.
- Able to calculate strength, predict failure and incorporate design considerations in shafts and beams.
- Able to apply and use energy methods to find force, stress and displacement in simple structures.
- Able to calculate stresses in open and closed sections in torsion and bending of standard sections.
- Able to apply stress functions, and calculate stresses in plates and shells, thick circular cylinders and discs and employ contact stresses and stress concentration knowledge.

Reference Books:

1. Srinath, L.S., Advanced Mechanics of Solids, Tata Mc-Graw Hill
2. Kumar K. and Ghai, R. C., Advanced Mechanics of Materials, Khanna Publishers
3. Shames, I.H., Mechanics of Deformable Solids, Prentice Hall of India
4. Popov, E.P., Engineering Mechanics of Solids, Prentice Hall of India
5. Ryder, G.H., Strength of Materials, B.I. Publishers

Pre Ph.D. (Mechanical Engineering)

Subject Code	ME964	Subject Title	Computer Control and Machining Tools						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1^{st}	Semester	I / II

Course Objective:-

- Advanced knowledge in the field of manufacturing
- Part Programming at basic and advanced level
- Basic information about Numeric Control at obsolete and advanced level
- Integration of CAD Design and machine tools

Unit 1: Introduction: Introduction to numerical control, basic concepts, advantages of NC, Structure of NC Systems.

Unit 2: N.C. Machine Tools: Types, Definition and designation of control axes, Constructional details of N. C. m/c tools, MCU structure and functions, Methods of improving accuracy and productivity using NC, Problems with conventional NC.

Unit 3: Part Programming: Block format and codes, Tool length and radius compensation, Flexible tooling, Tool path simulation on lathe and milling, Advanced programming features. Tooling For N. C. Machines: Tool and zero presetting, Work holding and setting up of CNC machine.

Unit 4: Numerical Control of M/c Tools: NC, Functioning of NC, MCU Organization, CNC, DNC, Adaptive control types, Uses & benefits, Advantages of CNC, DNC their structure, Combined CNC/DNC systems, CNC part programing

Unit 5: Computer Assisted Part Programming: Automatic NC program generation from CAD models; The APT language, Machining of surfaces, Introduction to Mould, Casting and Die design and manufacture using CAD/CAM software.

Course Outcome:-

- Students will be able to understand the difference and requirement of automation in the field of manufacturing
- Students will be able to do manual part programming
- Students will be able to generate the part program which would be used in machine tool from the modelling software.

Reference Books:

1. Koren, Y., Computer Control of Manufacturing systems, McGraw Hill.
2. Kundra, T. K., Rao, P. N. and Tewari, N. K., Numerical Control and Computer Aided Manufacture, McGraw Hill.
3. Koren, Y. and Ben-Uri, J., Numerical Control of Machine Tools, Khanna Publishers.
4. Groover, M. P. and Zimmers, E. W., CAD/CAM, Prentice Hall of India.

Pre Ph.D. (Mechanical Engineering)

Subject Code	ME965	Subject Title	Advanced Optimization Techniques						
LTP	4 0 0	**Credit**	**4**	**Subject Category**	DE	**Year**	1st	**Semester**	I / II

Course objectives:
To get familiar with the design, modeling, and its objectives.Also, to understand, and apply optimization in the analysis of various types of mechanical systems.

Syllabus

Unit I**Linear Programming:** Geometry of linear programming, Graphical method, Linear programming (LP) in standard form, Solution of LP by simplex and revised simplex methods, Exceptional cases in LP, Duality theory, Dual Simple method, Sensitivity analysis.

Unit II**Network Analysis:** Transportation problem (with transshipment), Assignment problem, Traveling-salesman problem, Shortest route problem, Minimal spanning tree, Maximum flow problem.

Unit III Integer Programming: Branch and bound algorithm, Traveling salesman problem.
Dynamic programming: Forward recursions, General problem, Reliability problem, Capital budgeting problem, Cargo-loading problem.

Unit IV **CPM and PERT:** Drawing of networks, Removal of redundancy, Network computations, Free slack, Total slack, Crashing, Resource allocation.

Unit V **Non-Linear Programming:** Characteristics, Concepts of convexity, maxima and minima of functions of n-variables using Lagrange multipliers and Kuhn-Tuker conditions, One dimensional search methods, Fibonacci, golden section method and gradient methods for unconstrained problems.

Course outcomes:
The students will be able to:
- Model the mechanical equipment's.
- Analyze and optimize the mechanical problems.
- Apply the mathematical techniques for control loops, stability analysis.

Reference Books:

1. Taha, H.A., Operations Research: An Introduction, Prentice Hall of India.
2. Kasana, H.S., Introductory Operation Research: Theory and Applications, Springer Verlag.
3. Rardin, Ronald L., Optimization in Operations research, Pearson Education.
4. Ravindran A, Phllips D.T. and Solberg J.J. Operation Research: Principles and Practice, John Wiley.

Pre Ph.D. (Mechanical Engineering)

Subject Code	ME966	Subject Title	Composite Materials						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1st	Semester	I / II

UNIT-I

Introduction: Definition, Reason for composites, classification of composites, Raw materials, classification, Chemistry, Properties and applications. Matrix: Thermoplastics-Raw materials, Physical and chemical properties, Thermal behaviour and mechanical properties, Thermosets-Epoxy; Curing reactions, Hardener, Gel time Viscosity Modifications, Prepreg making, Unsaturated polyester resin; catalyst, curing reaction, Viscosity modifier, Alkyd Resin, Vinly ester, polyimides, Physical and chemical properties, Thermal behaviour, Mechanical Properties and uses, Elastomeric composites.

UNIT-II

Reinforcements; Types, Properties, Uses of silica, Titanium dioxide, Talc, Mica, etc., Flake, Fibres -Structure, property and applications of natural and synthetic fibres, organic and inorganic fibres. Example: Glass, Carbon, Aramid, Nylon, Boron, Aluminium carbide, Silk, Jute, Sisal, Cotton, etc, Coupling agents.

UNIT-III

Processing : Thermoplastic, Thermosets, etc., Types of methods, Processing conditions advantages and disadvantages, Film forming, Lamination, Sandwich, etc., Hand Layup methods, compression and Transfer molding, Pressure and Vacuum bag process, Filament winding, Spin coating, Pultrusion, Reinforced RIM, Injection molding of Thermosets, SMC and DMC, Factors affecting the performance of Composites. Testing of Composites; Destructive and non-destructive tests, Tensile, Compression, Flexural, ILSS, Impact strength, HDT, Basic Concepts of fracture mechanism.

UNIT-IV

Composite product design, Fundamentals, Definitions, Structure -Material -Design relationships, Design methodologies, Material Considerations, Application of Composites-Aerospace, Transport, marine, Structural, Chemical and Corrosion resistant products, sports, electrical, Electronic, Communication, Biomedical Applications, Repairs and maintenance, etc., Nanocomposites: -Types, preparation, characterization and applications.

Reference Books:

1. Handbook of Composites by G. Lubin, Van Nostrand, New York, 1982.
2. Polymers and Polymer Composites in Construction L.C. Holleway,1990
3. Engineering plastics and Composites by John C.Bittence,1990
4. Handbook of Plastics, Elastomers and Composites by Charles A Harper,1975
5. Designing with Reinforced Composites - Technology Performance, Economics Rosato, 2nd ED.1997
6. Delwane Composite design Encyclopedia (Vol 3 Processing and Fabrication / Technology_ Ed. Leif A. Carlssen. and Joahn W. Hillispie, Technomic Publishing Ah. Lancaster U.S.A.
7. Fibre Glass Reinforced Plastics Nicholas P.Cheremisinoff and Composites Paul N.Cheremmisinoff., Noyes publications,N.J. U.S.A (1995)
8. Composite applications The Future is now, Thomas J. Drozdr, (Eds), Published by Society of Manufacturing Engineers, Michigan,1989.
9. Polymer Layered Silicate and silica nano Composites, Y.C.Ke,P.stroeve and F.s.Wang, Elesvier,2005
10. Hand Book of Plastics Testing Technology Vishu Shah, John Wiley & Sons, Inc NY. (1998)

Pre Ph.D. (Mechanical Engineering)

Subject Code	ME967	Subject Title	Computer Aided Design and Graphics						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1^{st}	Semester	I / II

UNIT-I Computer Graphics: Windowing and Clipping algorithms, Bresenham's Circle and ellipse generating algorithms, Three, Dimensional geometric transformations, multiple transformation.
Geometric Modelling: Dimensions of models, Types, Wire frame modeling, Solid modeling, Parametric representation of analytic curves-Line, Circle, Ellipse, parabola, hyperbola, conics.

UNIT-II -Parametric representation of Synthetic curves-Hermite cubic curves, Bezier curves, B-spline curves, rational curves. Curve manipulations-displaying, evaluating points on curves, Blending, segmentation, Trimming, Intersection. Surface models, surface entities, Parametric representation of analytic surfaces-planed and ruled surfaces, Surface of revolution, Tabulated cylinder, Parametric representation of synthetic surfaces-Hermitebicubic, Bezier and B-spline surfaces, Coons surface, offset surface, Triangular patches, sculptured surface, Rational parametric surface. Surface manipulations-Displaying, evaluating points & curves on surfaces, segmentation, Trimming, Intersection, Projection.

UNIT III- Assembly and Modelling Software Standards: Introduction, assembly modeling-Parts modeling and representation, Hierarchical relationships, Mating conditions. Inference of position from mating conditions. Representation schemes Graph structure, Location graph, Virtual link, generation of assembly sequences-Precedence diagram, Liasion-Sequence analysis, Precedence graph, Assembly analysis programs.

UNIT-IV Graphics database structure and handling, Operating features, Symbols, micros. Editing facility, Data selection, Graphic transformation, Plotting. Graphic standards-GKS and CORE, GKS-3D and PHIGS, IGES, Other graphic standards.

UNIT –V Introduction to Product Data Management (PDM): Present market constraints-need for collaboration Internet and developments in server-client computing. Components of PDM: Components of a typical PDM setup, hardware and document management, creation and viewing of documents, creating parts version, Control of parts and documents, case studies. Configuration Management: Base lines, product structure, configuration management, Products configuration, Comparison between sales configuration and products, Generic product modeling. Projects and roles: Creation of projects and roles, life cycle of a product, life cycle management, automation information flow, work flow, creation of work flow. Templates, life cycle, work now integration, Case studies.

Reference Books:

1. Computer Graphics D Hearn & M P Baker Prentice Hall
2. CAD/CAM Theory and Practice Ibrahim Zeid& R Sivasubramanian Tata McGraw-Hill
3. Principles of Computer Graphics W.M. Neumann and F Robert McGraw-Hill Co., Singapore
4. Principles of CAD J Rooney &P Steadman Longman Higher Education
5. CAD/CAM H P Groover and E W Zimmers Prentice Hall
6. PDM: Product data Management Rodger Burden Resource Publishing

Pre Ph.D. (Mechanical Engineering)

Subject Code	**ME968**	**Subject Title**	**Material Processing Techniques**						
LTP	4 0 0	**Credit**	**4**	**Subject Category**	DE	**Year**	1^{st}	**Semester**	I / II

Unit 1: Processing of Powder-Metal, ceramics, glass. Introduction. Production of Metal Powders,Compaction of Metal Powders,Sintering Secondary and Finishing Operations,Design Considerations,Process Capabilities,Ceramics, Glasses, and Superconductors

Unit 2: Processing and Equipment, Introduction Shaping Ceramics, Forming and Shaping of Glass Techniques for Strengthening and Annealing Glass

Unit 3: Surface Technology: Surface Roughness and Measurement; Friction, Wear, and Lubrication Introduction: Surface Structure and Integrity,Surface Texture and Roughness Friction,Wear, Lubrication, Metalworking Fluids and Their Selection.

Unit 4: Surface Treatments, Coatings, and Cleaning Introduction: Mechanical Surface Treatments ,Mechanical Plating and Cladding Case Hardening and Hard Facing, Thermal Spraying ,Vapor Deposition ,Ion Implantation and Diffusion Coating ,Laser Treatments ,Electroplating, Electroless Plating, and Electroforming Conversion Coatings,Hot Dipping Porcelain Enameling; Ceramic and Organic Coatings Diamond Coating and Diamond like Carbon, Surface Texturing, Painting Cleaning of Surfaces.

Unit 5: Experimental techniques of evaluation of friction in metal forming, influence of temperature and gliding velocity-friction and heat generation, friction between metal layers, surface treatment of drawing, sheet metal forming, extrusion and hot and cold forging. Processing of aluminum, cladding of AL alloys. Thermo mechanical Processing of Ferrous Alloys.

Reference Books:

1.Advanced Machining Processes, V.K.Jain, Allied Publications
2.Process and Materials of Manufacturing, R. A. Lindburg, 4th edition, PHI 1990
3. Manufacturing Engineering & Technology, 6/E, SeropeKalpakjian, Steven Schmid, PEARSON

Pre Ph.D. (Mechanical Engineering)

Subject Code	ME969	Subject Title	Numerical Methods						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1^{st}	Semester	I / II

Unit I Zeroes of transcendental and polynomial equation using Bisection method, Regula-falsi method and Newton- Raphson method, Rate of convergence of above methods.

Unit II Interpolation: Finite differences, difference tables, Newton's forward and backward interpolation, Lagrange's and Newton's divided difference formula for unequal intervals.

Unit III Solution of system of linear equations, Gauss- Seidal method, Crout method. Numerical differentiation, Numerical integration, Simpson's one third and three-eight rules, Solution of ordinary differential equations by Euler's, Picard's and forth-order Runge- Kuttamehthods.

Unit IV Statistical Techniques – I: Moments, Moment generating functions, Skewness, Kurtosis, Curve fitting, Method of least squares, Fitting of straight lines, Polynomials, Exponential curves etc., Correlation,Linear, non – linear and multiple regression analysis.

Unit V Statistical Techniques – II: Binomial, Poisson and Normal distributions, Sampling theory (small and large), Tests of significations: Chi-square test, z-test, Analysis of variance (one way) , Application to engineering, medicine, agriculture etc.

Reference Books:

1. Numerical Mathematical analysis, James B. Scarborough, Oxford and IBH Publishing Ltd
2. Optimization for Engineering Design - Algorithms and Examples, Kalyanmayi Deb, PHI Pvt. Ltd
3. Numerical Methods by Engineers by Steven C Chapra and Raymond P Canale, TMH Publications.
4. Numerical Methods for Engineers and Scientists, J D Hoffman, Marcel Dekker.
5. Numerical Methods, B. S. Garewal, Khanna Publishers Ltd.

Pre Ph.D. (Mechanical Engineering)

Subject Code	ME971	Subject Title	Experimental Design & Analysis						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1st	Semester	I / II

Unit I Stress: Introduction, Stress Equations of Equilibrium, Laws of Stress Transformations, principal Stresses, Strain: Introduction, Displacement and Strain, Strain Transformation Equation, Principal Strains, Stress Strain Relations, Strain Transformation Equations and Stress Strain Relations for Two-Dimensional State of Stress.

Unit II Strain Measurements: Introduction, Properties of Strain Guage Systems, Types of Strain Guages, Grid-Method of Strain Analysis. Failure Theories, Brittle Coating, Crack Patterns, Resin and Ceramic Based Brittle Coating, Test Procedure, Analysis of Brittle Coating Data.

Unit III Electrical Resistance Strain Gages: Introduction, Strain Sensitivity in Alloys, Strain Gage Adhesives, Gage Sensitivity and Gage Factor. Strain Gage Circuit: Potentiometer and its Application, Wheat-Stone Bridge, Bridge Sensitivity, Null Balance Bridges.

Unit IV System Theories: System Analysis, Black box approach, state theory approach, component integration approach, Decision process approach, A case study- automobile instrumentation panel system.

Unit V System modeling: Need of modeling, Model types and purpose, linear systems, mathematical modeling, concepts, A case study compound bar system.

Reference Books:

1. Doeblin E. O., “Measurements System Application and Design”, 5th Ed.,McGraw Hill.
2. Montgomery D. C., Design and Analysis of Experiments, John Wiley.
3. John P. W. M., Macmillan, Statistical Design and Analysis of Experiments.
4. Taneja H. C., Statistical Methods for Engineering and Sciences, IK International Publishing house Pvt Ltd.
5. Barnes J. Wesley, Statistical Analysis for Engineers And Scientists, McGraw Hill Inc.

Pre Ph.D. (Mechanical Engineering)

Subject Code	ME972	Subject Title	Material Characterization						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1^{st}	Semester	I / II

Unit I Introduction to the course: Relevance of advanced characterization to materials development, scientific understanding of phenomena in materials technology.

Advanced Diffraction Techniques: Introduction; X-Ray, their production & properties. Review of basic diffraction theory

Unit II - Various SAXS techniques and its applications in characterizing materials SAXS, GISAXS, LEED and RHEED, EXAFS, SEXAFS/NEXAFS

Unit III Surface Characterization - Advanced Surface Characterization Techniques: XPS, AES & SIMS, Importance of surface characterization techniques, Physical principles of XPS, Photoelectric effects, Instrumentation, XPS patterns; Spin orbital Splitting; Quantitative analysis, Chemical effect, Chemical shift, XPS imaging Auger electron generation; Principle, Chemical effect, Quantitative analysis, Depth profiling, Applications

Unit IV Comparison surface analysis techniques.Advanced Spectroscopic Techniques- Introduction, Electromagnetic spectroscopy, UV-Visible Spectroscopy, Photo-luminescence spectroscopy, Infra-red spectroscopy.

Unit V Advanced Microscopic Techniques: Introduction; Electron-materials interactions, TEM: HR, HAADF, STEM, In-situ TEM; SEM, EBSD, In-situ SEM.

Reference Books:

1. Sam Zhang, Lin Li and Ashok Kumar, Materials Characterization Techniques, CRC Press, (2008)
2. Yang Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Wiley & Sons (2008)
3. Elton N. Kaufmann, Characterization of Materials, Vol.1, Wiley & Sons (2003)
4. R.A. Laudise, Growth of Single Crystals, Prentice Hall, (1973)
5. G. Dhanaraj, K. Byrappa, V. Prasad and M. Dudley (Eds.), Springer Handbook of Crystal Growth, Springer-Verlag (2010)
6. Peter E.J. Flewitt and R.K. Wild, Physical Methods of Materials Characterization, 2nd Edition, Taylor & Francis (2003)
7. Willard, Merritt, Dean, Settle, Instrumental Methods of Analysis, CBS publishers & Distributors, Delhi, Sixth Edition, 1986.

Pre Ph.D. (Mechanical Engineering)

Subject Code	ME973	Subject Title	Advanced Manufacturing Techniques						
LTP	4 0 0	**Credit**	**4**	**Subject Category**	DE	**Year**	1^{st}	**Semester**	I / II

Unit:1 Development and classification of non-conventional manufacturing processes, considerations in processes selection. Mechanics of material removal, tool design, effects of process parameters on MRR, accuracy and surface finish and applications of the various non-conventional machining processes.

Unit:2. Ultrasonic Machining (USM), abrasive & water jet machining (AJM), Electro Chemical Machines (ECM),. Electro Chemical Grinding (ECG), Chemical Machining (CHM), Electrical Discharge (EDM),Machining

Unit 3: Electron Beam Machining (EBM) and lon Beam machining (IBM) processes. High Energy Rate Forming Methods (HERF).

Unit 4: Electrochemical Grinding, Electrical-discharge Machining, Laser-beam Machining, Electron-beam Machining, Water-jet Machining, Abrasive-jet Machining.

Unit 5: Hybrid Machining Systems, Economics of Advanced Machining Processes, High Velocity Forming of Metals, Explosive forming, Electro-hydraulic forming, magnetic pulse forming, Application of HE RF Techniques.

Reference Books:

1. Pandey & Shan, Modern Machining Processes, Tara McGraw Hill, N.Delhi
2. P.K Mishra, Non Conventional Machining, Narosa Publishing House, N.Delhi
3. Amitabh Bhattacharya, New Technology, Institution of Engrs (I) Calcutta
4. ASTME, High Velocity Forming of Metals, PHI, N.Delhi
5. Ghosh &Mullick, Manufacturing Science, New Age publishers Pvt. Ltd. N. Delhi
6. Serope Kalpak Jain & Steven R. Schmid, Manufacturing Engineering & Technology, Addison Wesley Ltd.. N. Delhi

Pre Ph.D. (Mechanical Engineering)

<table>
<tr><td>Subject Code</td><td>ME976</td><td>Subject Title</td><td colspan="9">Design of Experiments</td></tr>
<tr><td>LTP</td><td>4 0 0</td><td>Credit</td><td>4</td><td>Subject Category</td><td>DE</td><td>Year</td><td>1st</td><td>Semester</td><td>I / II</td></tr>
</table>

Unit 1: Introduction

Brief introduction of optimization techniques, Strategy of experimentation, Basic principles of Design, Terminology used in Design of Experiment, Guidelines for designing experiments, Basic statistical concepts: Types of Data, Graphical representation of Data, Measures of Central Tendency and Dispersion, Skewness.

Unit 2: Fitting Regression Models

Introduction, Linear regression models, Estimate of parameters in linear regression models, The method of least square, Hypothesis testing: Null Hypothesis, Alternative Hypothesis, Prediction of new response observations, Testing for lack of fit.

Unit 3: Factorial Design

Basic definition and principles, Advantages of factorials, Types of factorial design: Full factor factorial design and fraction factorial design, Design Matrix, Development of mathematical model, Regression model diagnostics.

Unit 4: Taguchi Method

Introduction, Concept design, Parameter design, Tolerance design, Orthogonal array experiments Taguchi quality loss function, Signal-to Noise ratio, Quality characteristics, Parameter optimization experiment, Parameter design case study.

Unit 5: Analysis Of Variance (ANOVA)

Introduction, One way ANOVA process, Two way ANOVA process, Degrees of freedom, Case studies on Factorial design, Taguchi Method and ANOVA.

Reference Books:

1. Montgomery D. C., Design and Analysis of Experiments, John Wiley.
2. John P. W. M., Macmillan, Statistical Design and Analysis of Experiments.
3. Taneja H. C., Statistical Methods for Engineering and Sciences, IK International Publishing house Pvt Ltd.
4. Barnes J. Wesley, Statistical Analysis for Engineers And Scientists, McGraw Hill Inc.

Pre Ph.D. (Mechanical Engineering)

Subject Code	**ME974**	**Subject Title**	**Conventional Welding Processes**						
LTP	4 0 0	**Credit**	**4**	**Subject Category**	DE	**Year**	1st	**Semester**	I / II

COURSE OBJECTIVES:
This course provides an understanding of the various manual and automated welding processes. It will also give the knowledge about the concepts, operating procedures, applications, advantages and limitations of various welding processes.

Unit 1:
Introduction: Welding– Definition, industrial importance, applications; advantages of welding over other fabrication processes; classification of welding and allied processes.
Fundamentals of Arc Welding & Power Sources: Arc- arc characteristics- arc physics, arc plasma, arc structure, arc stability, arc efficiency; brief introduction to bead geometry and melting rate, mode of metal transfer- short circuit, globular and spray mode of transfer, various factors and forces affecting metal transfer; welding power sources- introduction to transformers, rectifiers and inverters; power source characteristics- static and dynamic volt-ampere characteristics, duty cycle; arc blow- causes and its control.

Unit 2:
Shielded Metal Arc Welding (SMAW): Basic principle and equipment used; welding parameters and their effect on weld bead characteristics; covered electrodes- functions of electrode coating, types of coating and their characteristics, classification and coding of covered electrodes as per IS & AWS standards; advantages, limitations and applications.

Unit 3:
Gas Metal Arc Welding (GMAW): Basic principle and equipment used; welding parameters and their effect on weld bead characteristics; shielding gases- types, characteristics and applications; pulsed MIG welding; introduction to flux cored arc welding; advantages, limitations and applications.
Gas Tungsten Arc Welding (GTAW): Basic principle and equipment used; arc initiation method and arc stability; types of tungsten electrode and their applications; Purging techniques, shielding gases and their applications; effect of polarity on weld characteristics, requirement for DC suppresser unit; pulse TIG welding; electrode contamination; advantages, limitations and applications.

Unit-4:
Submerged Arc Welding (SAW): Basic principle and equipment used; welding parameters and their effect on weld bead characteristics; SAW fluxes- classification and their characteristics; coding of flux wire combination as per BIS and AWS; introduction to multi-wire and multi power systems, strip cladding, narrow gap welding; advantages, limitations and applications.

Unit- 5:
Plasma Arc Welding (PAW): Basic principle and equipment used; plasma forming and shielding gases; transferred and non-transferred arc modes; micro-plasma welding; advantages, limitations and applications.
Resistance Welding: Basic principle; Brief introduction to spot, seam, projection and flash butt welding; welding variables; heat shrinkage, heat balance; process capabilities and applications. Stud welding; Basic principle & applications.

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List of Experiments

1) To study the power sources used in welding processes.
2) Preparation of various joints by shielded metal arc welding (SMAW) process.
3) To investigate the effect of welding parameters on bead geometry using SMAW process.
4) To investigate the effect of welding parameters on bead geometry using gas metal arc welding (GMAW) process.
5) To investigate the effect of welding parameters on bead geometry using gas tungsten arc welding (GTAW) process.
6) To study the effect of polarity on depth of penetration in SMAW process.
7) To study the effect of polarity on bead profile using gas tungsten arc welding (GTAW) process.
8) To study the effect of shielding gas on bead profile using gas metal arc welding (GMAW) process.
9) To study the effect of shielding gas on bead profile using gas tungsten arc welding (GTAW) process.
10) To perform nugget test on spot welded specimen.

TEXT BOOKS

1. Parmar R. S., Welding Processes & Technology, Khanna Publishers.
2. Nadkarni S. V., Modern Arc Welding Technology, Oxford & IBH.
3. Smith Dave, Welding skills and technology, McGraw Hill.
4. Little R., Welding Technology, TMH.

COURSE OUTCOMES:

After completing this course, the students can :
CO1: Develop understanding of a broad classification of the various welding processes.
CO2: Develop a fundamental knowledge of basic principle of SMAW process.
CO3: Understand the fundamental principles of GMAW and GTAW processes.
CO4: Develop a fundamental knowledge of basic principle of SAW process.
CO5: Understand the fundamental principles of plasma arc welding and resistance welding processes.

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Subject Code	**ME975**	**Subject Title**	**Inspection and Testing of weldments**						
LTP	4 0 0	**Credit**	**4**	**Subject Category**	DE	**Year**	1^{st}	**Semester**	I / II

COURSE OBJECTIVES:
This course provides an understanding of the basic principles of various testing, inspection and characterization tools, and use of those tools to analyze metallurgical components.

Unit 1:
Introduction: Quality-Weld quality, quality assurance concept in welding; brief introduction to procedure and welder's qualification, requirement of destructive and non-destructive testing for quality control of welds.
Welding defects, classification of weld defects, arc welding defects: surface defects like cracks, incorrect weld profile, distortion, undercuts, overlaps, dimensional defects, under fill, burn through, spatter, as well as sub-surface defects; sub-surface defects like lack of fusion, cracks, lack of penetration, blowholes, porosity, inclusions etc.

Unit 2:
Destructive testing (DT) in welding:Service weldability tests: Tension tests: All weld metal test, longitudinal butt weld test, transverse butt weld test; Bend tests: Free bend test, guided bend test, controlled bend test; Impact testing: Charpy and Izod tests; Hardness tests: Brinell, Vickers, Rockwell hardness tests, micro-hardness test; Fatigue test-Fatigue failure, test procedure, recording of fatigue data, S-N diagram, Goodman diagram.

Unit 3:
Visual inspection of welds; Liquid penetrant testing: dye penetrant testing – procedure, penetrant testing materials, penetrant testing method, sensitivity; applications and limitations.
Magnetic Particle Testing (MPT): definition and principle, longitudinal vs. circular magnetization, different magnetizing techniques, procedure, equipment sensitivity and limitation.
Eddy current: principle, instrument techniques, sensitivity, application and limitations.

Unit-4:
Radiography Testing (RT): Production and properties of X-rays, X-ray sources; Basic principle and procedure; radiographic imaging- sensitivity, film speed, exposure time, film density, image quality indicators; inspection techniques- single and double wall imaging techniques; applications and limitations; real time radiography; safety against radiation hazards.

Unit- 5:
Ultrasonic testing: principle of UT, basic properties of sound beam, ultrasonic transducers, inspection methods, technique for normal beam inspection, weld testing using angular probes, modes of display, immersion testing, advantage, limitations.
Acoustic emission testing: principles of AET.

TEXT BOOKS

1. Parmar R. S., Welding Engineering & Technology, Khanna Publishers.
2. Nadkarni S. V., Modern Arc Welding Technology, Oxford & IBH.
3. Raj Baldev, Jayakumar. T., Thavasimuthu.M., Practical Non Destructive Testing, Narosa.

COURSE OUTCOMES:
After completing this course, the students can:
CO1: Understand the requirement of destructive and non-destructive testing of welded joints.
CO2: Develop a fundamental knowledge of welding defects.
CO3: Understand the basic principle of various destructive testing used for welded joints.
CO4: Develop a fundamental knowledge of different non-destructive testing used for welded joints.