Fourth Year I - Semester

Code	Name of the subject	Periods per week				Max. marks		Credits
			Lecture	Tutorial	Practical	Sessional	End Exams	
MEC411	Open elective –II	OE	3	1		40	60	3
MEC412	Managerial Economics and Financial Analysis	PC	3	1		40	60	3
MEC413	Heat Transfer	PC	4	1		40	60	4
MEC414	Computer Aided Design	PC	3	1		40	60	3
MEC415	Dept Elective –II	PE	3	1		40	60	3
MEC416	Dept Elective –III	PE	3	1		40	60	3
MEC417	Heat Transfer Lab	PC			3	50	50	2
MEC418	Computer Aided Design Lab	PC			3	50	50	2
MEC419	Industrial Training**	IT				100		2
MEC420	Project -Phase –I	PW			5	100		4
Total			***19***	***6***	***11***	***540***	***460***	***29***

Fourth Year II - Semester

Code	Name of the subject	Periods per week				Max. marks		Credits
			Lecture	Tutorial	Practical	Sessional	End Exams	
MEC421	Instrumentation &Control systems	PC	3	1		40	60	3
MEC422	Dept Elective – IV	PE	3	1		40	60	3
MEC423	Project Phase –II	PW			12	100	100	8
MEC424	MOOCs ##	OE				100		2
Total			***6***	***2***	***12***	***280***	***220***	***16***

MANAGERIAL ECONOMICS AND FINANCIAL ANALYSIS	
MEC 412	**Credits:3**
Instruction : 3periods & 1Tut/Week	Sessional Marks :40
End Exam : 3hrs	End Exam Marks: 60

Prerequisites: -NIL

Course objectives: To make the students to learn the fundamentals of managerial economics and explain the concepts of costs and break – even analysis. To acquaint the students with the different market situations and forms of business organization. To impart the knowledge of financial accounting.

Course outcomes:

CO'S	CO DESCRIPTION
CO1	Differentiate micro vs macroeconomics and apply the concepts of demand analysis & demand forecasting
CO2	Explain the cost concepts and types of costs and further evaluate Break-even point.
CO3	Identify classes of market structures, business organizations and phases of business cycles
CO4	Differentiate fixed and working capital and Explain the methods and sources of finance.
CO5	Prepare balance sheet of a business organization with sole proprietor.

Mapping of course outcomes with program outcomes:

CO'S	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1							1	1	1	1
CO2	1	1							1	1	1	1
CO3									1	1	1	1
CO4									1	1	1	1
CO5	1	1							1	1	1	1

SYLLABUS

Periods

(L+T)

UNIT-I **(9+3)**

Introduction to Managerial Economics: Definition; micro and macroeconomics; demand analysis - demand determinants, law of demand and its exceptions, elasticity of demand; demand forecasting - survey methods, statistical methods.

UNIT-II **(9+3)**

Cost Analysis: Cost concepts - opportunity cost, fixed vs. variable costs, explicit vs. implicit costs, out ofpocket vs. imputed costs; Break Even Analysis -determination of break-even point (simple problems)**.**

UNIT-III **(12+0)**

Market Structures: Types of competition; features of perfect competition; imperfect competition monopoly, monopolistic competition.

Types of Business Organization and Business Cycles: Sole trader; partnership; joint stock company; pubic enterprises; business cycles - definition and characteristics, phases of business cycle.

UNIT-IV **(11+1)**

Capital –Types and Sources: Fixed and working capital; methods and sources of finance.

UNIT-V **(9+3)**

Introduction to Financial Accounting: Final accounts of a sole proprietor - preparation of tradingaccount, profit and loss account, balance sheet.

Text Books:

1. Managerial Economics and Financial Analysis by A. R. Aryasri; McGraw-Hill Education (India)Private Limited, New Delhi (2015).

2. Engineering Economics, Volume I by Tara Chand; Published By Nem Chand & Bros, Roorke (2007).

Reference Books:

1. Managerial Economics by Varshney & Maheswari; Published by Sultan Chand, 2007.

2. Financial Accounting by Shim &Siegel; Published by Schaum's Outlines, TMH 2007.

Web Resources:

http://www.nptel.ac.in

http://www.freevideolectures.com

HEAT TRANSFER	
MEC 413	**Credits : 4**
Instruction : 4 Periods & 1 Tut/Week	Sessional Marks : 40
End Exam : 3 Hours	End Exam Marks : 60

Prerequisites:

Mathematics-I, Fluid Mechanics, Engineering Thermodynamics-1

Course Objective:

- To acquaint the students with the principles involved in the modes of heat transfer and few of its applications in engineering equipment.

Course Outcomes:

CO'S	CO DESCRIPTION
CO1	Analyse and evaluate the heat transfer rate in 1D Steady state heat transfer applications.
CO2	Assess the temperature distribution and evaluate effectiveness and fin efficiency for different cross-sections and further determine temperature distribution in bodies of regular cross-sections under un-steady state heat transfer condition.
CO3	Explain the mechanisms of convection, significance of non-dimensional numbers and apply suitable correlations for evaluating the heat transfer coefficients in different flows under free and forced convection.
CO4	Explain the regimes of pool boiling, flow boiling, types of condensation and determine the heat transfer rates and areas in heat exchangers.
CO5	Elucidate the laws governing radiation heat transfer, evaluate the radiation properties and determine the heat exchange by radiation between bodies.

Mapping of course outcomes with program outcomes:

Strong -3, Medium -2, Low -1

CO'S	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**2**	**2**	**1**						**1**	**1**		**1**
CO2	**2**	**2**	**1**						**1**	**1**		**1**
CO3	**2**	**2**	**1**						**1**	**1**		**1**
CO4	**2**	**2**	**1**						**1**	**1**		**1**
CO5	**2**	**2**	**1**						**1**	**1**		**1**

SYLLABUS

Periods (L + T)

UNIT-I Conduction Heat Transfer (12 + 8)

Basic Concepts:

Mechanism of heat transfer, basic laws of heat transfer, thermal conductivity, concept of driving potential, thermal resistance and electrical analogy; Generalized heat conduction equations in Cartesian, Cylindrical & Spherical coordinate systems.

One-Dimensional Steady conduction:

Systems without internal heat generation – Steady state heat conduction through plate, composite-slabs, cylinders & spheres; Variable thermal conductivity; Critical radius of insulation.

UNIT-II Extended Surfaces & Unsteady Heat Conduction (8 + 4)

Extended Surfaces:

Heat conduction through fins of uniform cross section only – Fin efficiency & effectiveness.

Transient heat conduction (One-Dimensional):

Lumped system analysis, systems with negligible surface resistance, semi-infinite bodies, Heisler's chart and Groover chart solutions.

UNIT-III Convective Heat Transfer (12 + 6)

Fundamentals:

Mechanisms of convection, Nusselt number, Velocity boundary layer – Surface shear stress, thermal boundary layer, Prandtl number, Laminar & turbulent flows – Reynolds number, Differential convection equations in 2D – review of continuity, momentum equations (without derivations), energy equations derivation, Blausius similarity solution for flat plate, Analogies – Reynolds, Colburn analogies, Significance of non-dimensional numbers.

Forced & Free Convection:

External flow – correlations for heat transfer coefficient and friction coefficients – laminar and turbulent flow over flat plate. Internal flow – Hydrodynamic & Thermal entry lengths – developing & fully developed flows, Use of empirical relations for flow through tubes. Mechanism of natural convection, development of hydrodynamic & thermal boundary layer along vertical plate, use of correlations for heat transfer – for vertical, horizontal and inclined plates.

UNIT-IV Heat Transfer with Phase Change & Heat Exchangers (8 + 5)

Boiling & Condensation:

Boiling: Pool boiling regimes – Pool boiling correlation, flow boiling inside tube.

Condensation: Laminar film wise condensation, Nusselt's theory condensation on vertical flat plate, horizontal tubes, drop-wise condensation.

Heat Exchangers:

Classification of Heat Exchanger, Overall heat transfer coefficient, fouling in heat exchanger, Analysis of heat exchanger – LMTD method and NTU method (parallel & Counter flow only)

UNIT-V Radiation Heat Transfer (8 + 4)

Fundamentals:

Introduction, Electromagnetic wave spectrum, Thermal radiation; Black body radiation – Stefan Boltzman's law, Plank's law, Wein's Displacement law; Radiation intensity – Lambert's cosine law; Radiation properties – Emissivity, absorptivity, reflectivity, transmissivity, Kirchoff's law;

Radiation heat exchange between surfaces:

Shape factor, shape factor algebra; Radiation in non-absorbing media – Radiosity; Radiation heat transfer between gray bodies, electrical analogy, radiation heat transfer in two surface enclosure, radiation shields.

Text Books:

1. Dr. Sachdeva, *Fundamentals of Engineering Heat and Mass Transfer*, edition 4, New Age International Publishers Limited, 2010.
2. A.F. Mills & V. Ganeshan, *Heat Transfer*, edition 2, Pearson Publishers, 2009.

Reference Books:

1. Er. R.K. Rajput, *Heat and Mass Transfer*, edition 4, S. Chand Limited, 2007.
2. Heat and Mass Transfer: Fundamentals and Applications, Yunus A Cengel; Afshin J. Ghajar, 5th Editiion, Tata Mc Graw Hill.

Data Book:

1. Heat and Mass Transfer Data Book , C.P.Kothandaraman , S. Subramaniam, 8th Edition, New Age International Publishers Limited.

COMPUTER AIDED DESIGN	
MEC 414	**Credits : 3**
Instruction : 3 Periods & 1 Tut/Week	Sessional Marks : 40
End Exam : 3 Hours	End Exam Marks : 60

Prerequisites:

C-Programming Lab, Engineering Drawing, Machine Drawing, Strength of Materials, DMM-I and DMM-II.

Course Objective:

To introduce students the fundamentals of CAD, Geometric modeling, capabilities of CAD packages, CAD approach for design problems & Artificial intelligence.

Course Outcomes:

CO'S	CO DESCRIPTION
CO1	Explain the usage of computer peripherals and Graphic display devices.
CO2	Develop database for wire-frame model and design tree for solid model.
CO3	Apply various FEM packages for solving problems in mechanical engineering.
CO4	Write the algorithms for solving mechanical design problems.
CO5	Apply the technique of Artificial Intelligence to design problems.

Mapping of course outcomes with program outcomes:

CO'S	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1				1							1		
CO2	1	2	2		1							1	1	
CO3	1	2	3		1							1	1	
CO4	1	2	2		1							1	1	
CO5	1	2	1											

SYLLABUS

Periods (L +T)

UNIT-I **(7+1)**

Fundamentals of CAD:

Introduction - The design process - Application of computers for design - Operating systems - Hardware in CAD: The design work station - I/O Devices - CAD system configuration - Creating database for manufacturing - Benefits of CAD.

Interactive Computer Graphics - Graphic display devices- Graphics system- Graphics standards - Graphical user interface

UNIT-II **(16 +2)**

Geometric Modeling:

Modeling Techniques - Wire frame Modeling - Surface Modeling - Solid Modeling; half space method, B-rep, CSG, sweep representation, analytical solid modeling, primitive instancing, and spatial partitioning. 2D and 3D transformations, windowing and clipping.

UNIT-III **(11 + 1)**

Capabilities of CAD packages:

Introduction to Finite Element Analysis - CAD techniques to finite element data preparation- Automatic mesh generation- presentation of results – 3 dimensional shape description and mesh generation- CAD applications of FEM. Introduction to CAD packages like ANSYS, NASTRON, NISA.

UNIT-IV **(12 + 4)**

CAD approach for design problems:

Computer aided design approach for coil springs, spur gear, disk clutches, internal expanding shoe brake and kinematics of slider crank mechanism. CAD approach for cross sectional area and centroid of L, T and I sections.

UNIT-V **(5 + 1)**

Artificial Intelligence:

Introduction - Expert system and its structure, Building an expert system. Applications of AI in design and CAD.

Text Books:

1. CAD/CAM- Computer Aided Design & Manufacturing, by M.D.Groover & E.W.Zimmer, 1stEdition, PEARSON Publication, 2003.
2. Computer Aided Design and Manufacturing, by Dr.Sadhu Singh, Khanna Publishers, 5th Edition, Khanna Publisher, 2015.

References:

1. Computer Aided Design in Mechanical Engineering, by V.Rama Murthy, 3rd Edition, McGraw-Hill, 1998.
2. Elements of Computer Aided Design & Manufacturing, by Y.C.Pao, 1st edition, Wiley publications, 1984.
4. Computer Aided Design and Manufacturing, by C.B.Besant & C.W.K.Lui, 3rd edition , Ellis Horwood Ltd, 1985.
5. Computer-Aided Analysis & Design by S. Ghosal, Prentice Hall of India, Prentice Hall India Learning Private Limited,1997.
6. CAD/CAM/CIM by Radhakrishna, New Age International Pvt. Ltd. Publishers, 2009.

Web Resources:

1. http://nptel.ac.in/courses/Webcourse-contents/IIT-Delhi/Computer%20Aided%20Design%20&%20ManufacturingI/index.htm
2. http://www.mrrtechnical.co.in/#cad

GAS TURBINES AND JET PROPULSION	
MEC415 (A)	**Credits : 3**
Instruction : 3 Periods & 1 Tut/Week	Sessional Marks : 40
End Exam : 3 Hours	End Exam Marks : 60

Prerequisites: Engineering Thermodynamics – I, III & Fluid Mechanics

Course Objective:

To provide an insight on the principles of compressible fluid flow, gas turbine power cycles and further to create an understanding of the working principles of axial flow compressors, axial flow gas turbines, combustion chambers and jet propulsion systems.

Course Outcomes:

By the end of the course, the student will be able to:	
1.	Analyze compressible fluid flow and its characteristics
2.	Explain the working principles of gas turbine power cycles and evaluate their performance characteristics.
3.	Comprehend the working characteristics of Axial flow compressors, evaluate the effect of blade design on the performance and further analyze operational disturbances.
4.	Explain the combustion phenomena in a gas turbine & the working principles of Axial flow gas turbines.
5.	Distinguish the different types of jet propulsion systems and their relative merits and demerits and their applications.

Mapping of course outcomes with program outcomes:

	PO											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO 1	2									1		
CO 2	2	1								1		1
CO 3	2	2	2	1	1				2	1		1
CO 4	2	2	2	1		2	2		1	1		1
CO5	1	2								1		

SYLLABUS

Periods

(L + T)

UNIT-I **(8 + 2)**

Introduction to compressible flow

Introduction- Conservation of Mass - Continuity Equation- Conservation of Energy (First Law of Thermodynamics)- Momentum Equation- Sonic Velocity, Mach Number and Mach Waves- Stagnation Temperature, Pressure and Enthalpy- Isentropic Flow Through a Passage of varying cross sectional Area- choking and isentropic flow, operation of nozzle under varying pressure ratio- converging, converging-diverging nozzle.

UNIT-II **(8 + 2)**

Gas Turbine Power Cycles

Introduction- Brayton Cycle- Brayton Cycle with Regeneration- Complex Cycle- Closed Cycle, Performance of actual gas turbine cycle: Efficiency of the compressor and Turbine- Pressure or Flow Losses- Heat Exchanger Effectiveness- Effect of varying mass Flow-Loss due to incomplete combustion- Mechanical Losses- Effect of Variable Specific Heats - Calculation of Fuel consumption and cycle Efficiency- Polytropic Efficiency- Performance of Actual Cycles.

UNIT-III **(12+ 3)**

Axial Flow Compressors

Introduction- Description- Principle of Operation- Performance Analysis- Momentum, Stage Velocity Diagrams, Symmetric Stage, Non-Symmetric Axial -in flow, Non-Symmetric Axial-outflow- Actual Energy Transfer- Aero foil Analysis, One Dimensional Ideal Incompressible Flow, Two Dimensional flow With Friction- Blading Efficiency, Losses in terms of Air Angles and Drag Co efficient- Coefficient of Performance, Flow Coefficient (Φ), Pressure Coefficient (ψ_p),Work Coefficient(Ω)- Blade Loading- Cascade Characteristics-Blade angles- Reynolds and Mach Number Effects- Three Dimensional flow Analysis, Radial Equilibrium Theory, Free Vortex Blades, Constant Reaction Blades, Forced Vortex of Solid Rotation Blades, The General Design -Three Dimensional Blades, Losses- Compressor Stall, Surge and choke- Overall Performance- Compressor Characteristics.

UNIT-IV **(13+ 2)**

Combustion Systems

Introduction- Combustion theory applied to gas turbine combustion, factors affecting combustion chamber design and performance – Pressure loss, Combustion intensity and Efficiency;

Requirements of the Combustion chamber- Process of Combustion- Combustion geometry, mixing and dilution, Combustion chamber arrangements.

Axial Flow Gas Turbines

Introduction- Description- Turbine and Nozzle efficiencies- Degree of Reaction, Ideal Impulse Turbine, Impulse Turbine with Loss, Blades Speed Ratio, Velocity Ratio and Torque, Velocity Compound Turbine (Curtis Stage)- The Reaction Turbine- Three Dimensional Flow Analysis, The Free Vortex Blades

UNIT-V **(8+ 2)**

Jet Propulsions

Introduction-The Ramjet Engine-The Pulse-jet Engine- The Turbo-jet Engine-Thrust Equation-Specific Thrust of the Turbo Jet Engine- Efficiencies- Inlet Diffuser or Ram Efficiency- thermal Efficiency of the Turbo Jet Engine- Propulsive Efficiency - Overall Efficiency of a Propulsive system-parameters affecting flight performance, Effect of Forward Speed- Effect of Altitude - Overall Turbojet Process- Thrust augmentation- The After burn, Injection of Water-Alcohol Mixtures- Bleed, Burn Cycles.

Text Books:

1. V. Ganesan, *Gas Turbines*, 3rd edition, McGraw Hill Education, 2017.
2. P.R. Khajuria and S.P. Dubey, *Gas Turbines and Propulsive Systems,* Dhanpat Rai Publiations, 2012.

Reference Books:

1. Dr. R. Yadav ,*Steam and Gas turbine and Power plant Engineering*,7th edition, Central Publishing House, 2000.
2. H.I.H. Sarvanamuttoo,G.F.C. Rogers & H. Cohen, *Gas Turbines Theory*, 7th edition, Pearson Publications, 2017

Web Resources:

1. http://www.nptel.ac.in/courses/112106166/

PRODUCT DESIGN AND MANUFACTURING	
MEC 415 (B)	**Credits : 3**
Instruction : 3 Periods & 1 Tut/Week	Sessional Marks : 40
End Exam : 3 Hours	End Exam Marks : 60

Prerequisites:

Manufacturing Technology-1, Material Science, Design of Machine Elements-I

Course Objective:

- To acquaint the students with the design process and models as applied to various manufacturing processes and materials and further introduce them to Value Engineering and environmental factors in the design process

Course Outcomes:

By the end of the course, the student will be able to:	
1.	Explain the generalized design process and analyze various key design models
2.	Analyze the type of failure and determine geometric dimensions and stresses on mechanical components subjected to various types of stresses
3.	Apply various strategies in the product design process
4.	Apply design processes for manufacturing techniques like injection molding and machining.
5.	Analyze economics and human ergonomic factors in design and explain basics of value engineering and environmental factors in the design process

Mapping of course outcomes with program outcomes:

	PO											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO 1	1	3	2	1				2	2	1		
CO 2	1	3	2	1				1		1		
CO 3	1	3	2	1				1	1	1		
CO 4	1	3	2	1				1		1		
CO5	1	3	2	1		3	2	1	2	1	2	1

SYLLABUS

Periods

(L +T)

UNIT-I **(11+1)**

Design philosophy:

Introduction to product design and manufacturing, Product design: definition, and evolution.,Product design morphology, Product design morphology: Preliminary ,and detailed design.Design process, Problem formation, Introduction to product design, Various design models-Shigley model, Asimov model and Norton model, Need analysis, Strength considerations -standardization. Creativity, Creative techniques, Material selections and its criteria, Notches and stress concentration, design for safety and Reliability

UNIT-II **(13 +1)**

Failure theories:

Fracture mechanics theory, Fatigue mechanisms, Fatigue failure models, Design for fatigue strength and life, creep: Types of stress variation, design for fluctuating stresses, design for limited cycles, multiple stress cycles, Fatigue failure theories ,cumulative fatigue damage, thermal fatigue and shock, harmful and beneficial residual stresses, Yielding and transformation

UNIT-III **(9+ 1)**

Product Design:

Product flowcharting, Creativity techniques, Translating customer needs, Product Development process ,Product strategies, Product value, Product planning, Product specifications, Product Concept generation, Concept selection, Concept testing.

UNIT-IV **(10 + 2)**

Design for Machining and Injection Molding:

Machining Using Single-Point & Multi point cutting tools, Choice of Work Material, Shape of Work Material, Machining Basic Component Shapes, Cost Estimating for Machined Components, Injection Molding Materials, The Molding Cycle, Injection Molding Systems, Molding Machine Size, Molding Cycle Time.

UNIT-V **(12+ 2)**

Economic And Environmental factors in design:

Economic analysis, Human engineering considerations, Ergonomics, Design of controls, Design of displays. Value Engineering: a product design approach, Elements of Value Engineering, Value Engineering tools, Case study in Value Engineering, Material and process selection in value engineering, Modern approaches in design, Techniques to reduce Environmental Impact

Text Books:

1. A.K. Chitale and R.C. Gupta, *" Product Design and Manufacturing"*, Prentice Hall.

2. Joseph Shigley and Mischke, *" Mechanical Engineering Design",* 6th th edition, Tata McGraw Hill.

Reference Books

1. R.L. Norton, *" Machine Design - An Integrated Approach"* , Prentice Hall.
2. Karl T. Ulrich and Steven D. Eppinger, *" Product design and development"*. 3rd edition,Tata Mc GrawHill.

Web Resources:

1. https://www.vidyarthiplus.com/vp/attachment.php?aid=42037
2. http://www.howdoesacarwork.com/p/1-engines_10.html

3. http://www.nptelvideos.in/2012/12/design-of-machine-elements.html

ROBOTICS	
MEC 415 (C)	**Credits:3**
Instruction : 3periods & 1Tut/Week	Sessional Marks :40
End Exam : 3hrs	End Exam Marks: 60

Course objective:

To familiarize the students with the automation and brief history of robot development, impart knowledge on kinematics of robots, robot end effectors and their design, various sensors and their applications in robots and further acquaint them with robot programming methods, languages of robot & machine vision and artificial intelligence of robots.

Course outcomes:

By the end of the course, the student will be able to:	
CO-1	Elucidate the fundamental principles of Robot Technology, Programming, and Applications
CO-2	Explain the Control Systems and Components of a robot and further analyze robot Motion and its Control.
CO-3	Write programmes in various methods to control a robot for simple applications.
CO-4	Explain the nuances of machine vision and artificial intelligence as applied to the field of robotics.
CO-5	Describe the applications of robots in Material Transfer, Machine Loading/Unloading, Assembly, Inspection and various other Processing operations

Mapping of course outcomes with program outcomes:

		PO											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO	**1**	2	1				1			1	1	1	1
	2	2	2	1	1		1			1	1	1	1
	3	1	1	1	1	2	1			1	1	1	1
	4	1	1	1		1	1			1	1	1	1
	5			1			2			1	1	1	1

SYLLABUS

(L+T)

UNIT 1 Fundamentals of Robotics (6+4)

Introduction

Automation and Robotics, A Brief History of Robotics, The Robotics Market and the Future Prospects.

Fundamentals of Robot Technology, Programming, and Applications

Robot Anatomy, Work Volume, Robot Drive Systems, Control Systems, Precision of Movement, End Effectors, Robotic Sensors, Robot Programming and Work Cell Control, Problems.

UNIT 2 The Robot and its Peripherals (12+4)

Control Systems and Components

Basic Control Systems Concepts and Models, Controllers, Control System Analysis, Robot Transducers and Sensors, Tactile Sensors, Proximity and Range Sensors, Velocity Sensors, Miscellaneous Sensors, Robot Actuators, Robot End Effectors -Types of End Effectors, Mechanical Grippers, Other Types of Grippers, Tools as End Effectors, Considerations in Gripper Selection and Design, Power Transmissions Systems, Modeling and Control of a Single Joint Robot, Problems.

Robot Motion Analysis and Control

Introduction to Manipulator Kinematics, Homogeneous Transformations and Robot Kinematics, Manipulator Path Control, Robot Dynamics, Configuration or a Robot Controller, Problems

UNIT 3 Robot Programming and Languages (12+4)

Robot Programming

Methods of Robot Programming, Lead through Programming Methods, A Robot Program as a Path in Space, Motion Interpolation, Wait, Signal, and Delay Commands, Branching, Capabilities and Limitations of Lead through Methods.

Robot Languages

The Textual Robot Languages, Generations of Robot Programming Languages, Robot Language Structure, Constants, Variables, and Other Data Objects, Motion Commands, End Effector and Sensor Commands, Computations and Operations, Program Control and Subroutines, Communications and Data Processing, Monitor Mode Command.

UNIT 4 Machine Vision and Artificial Intelligence of Robots (8+2)

Machine Vision

Introduction to Machine Vision, The Sensing and Digitizing Function in Machine Vision, Image Processing and Analysis, Training the Vision System, Robotic Applications.

Artificial Intelligence

Introduction, Goals of AI Research, AI Techniques, LISP Programming, AI and Robotics, LISP in the Factory, Robotic Paradigms

UNIT 5 Robot Applications in Manufacturing (7+1)

Material Transfer, Machine Loading/Unloading and Processing operations

General Considerations in Robot Material Handling, Material Transfer Applications, Machine Loading and Unloading, Processing Operations- Spot Welding, Continuous Arc Welding, Spray Coating, Other Processing Operations using Robots

Assembly and Inspection

Assembly and Robotic Assembly Automation, Parts Presentation Methods, Assembly Operations, Compliance and the Remote Center Compliance (RCC) Device, Assembly System Configurations, Adaptable-Programmable Assembly System, Designing for Robotic Assembly, Inspection Automation

Text Books:

1. Mikell P. Groover, Mitchell Weiss ,Roger N. Nagel Nicholas G. Odrey, Industrial Robotics-Technology, Programming, and Applications, 2nd edition, McGraw-Hill Higher Education ©1986
2. Lung-Wen Tsai, Robot Analysis- The Mechanics of Serial and Parallel Manipulators, JohnWiley & Sons,1999

Reference Books:

1. King-Sun Fu, R.C. Gonzalez and C.S.George Lee, Robotics Control Sensing Vision And Intelligence, 1st edition, Mc Graw-Hill Education International Ed (1987)
2. John J. Craig, Introduction to Robotics - Mechanics and Control, 3rd edition, Addison-Wesley Longman Inc., 1999.

Web Resources:

https://www.youtube.com/watch?v=0yD3uBshJB0

TOTAL QUALITY MANAGEMENT	
MEC 415 (D)	**Credits:3**
Instruction : 3periods & 1Tut/Week	Sessional Marks :40
End Exam : 3hrs	End Exam Marks: 60

Prerequisite: Industrial Engineering and Management.

Course Objectives: To acquaint the students basic concepts of quality and quantity from organizational point of view and the concept of western and Japanese approaches and processes, the internal politics, quality culture, education and training of the organization. The objective is also to familiarize the students about international/national Quality systems and various industrial oriented TQM methods.

Course Outcomes:

By the end of the course, the student will be able to:	
1.	Explain the quality environment and TQM philosophies.
2.	Describe TQM processes and Brain storming methods.
3.	Elucidate QPD & QFD for customer satisfaction.
4.	Explain international/national Quality systems.
5.	Analyze various industrial oriented TQM methods.

Mapping of Course Outcomes with Programme Outcomes.

High-3, Medium-2, Low-1

	PO1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**	**PO-9**	**PO-10**	**PO-11**	**PO-12**
CO-1		1	2	1	1	1	1	1	1	1	2	1
CO-2	2	1		2	3	3	2	2	2	1	3	1
CO-3	1	1	2	1	2	2	1	2	3	3	3	2
CO-4	1	1	1	1	1	2	3	3	1	1	3	1
CO-5	2	2	1	1	1	1	2	1	2	3	2	1

Syllabus

Periods

UNIT-I **(L +T)**

Concepts of TQM: **(10+2)**

Philosophy of TQM, Customer focus, Organization, Top management commitment, Team work, Quality philosophies of Deming, Crossby and Muller.

UNIT-II

TQM process: **(10+2)**

QC tools, Problem solving methodologies, New management tools, Work habits, Quality circles, Bench marking, Strategic quality planning.

UNIT-III

TQM systems: **(10+2)**

Quality policy deployment, Quality function deployment, Standardization, Designing for quality, Manufacturing for quality.

UNIT-IV

Quality system: **(10+2)**

Need for ISO 9000 system, Advantages, Clauses of ISO 9000, Implementation of ISO 9000, Quality costs, Quality auditing, Case studies.

UNIT-V

Implementation of TQM: **(6+6)**

Steps, KAIZEN, 5S, JIT, POKAYOKE, Taguchi methods, Case studies.

Text Books:

1. Total Quality Management by Rose, J.E., Kogan Page Ltd., 1993.
2. The Essence of Total Quality Management by John Bank, PHI, 1993.

Reference Books:

1. Beyond Total Quality Management by Greg Bounds, Lyle Yorks et al, McGraw Hill, 1994.
2. The Asian Productivity Organization by Takashi Osada, 1991.
3. KAIZEN by Masaki Imami, McGraw Hill, 1986.

Web Resources:

http://www.nptel.ac.in

http://www.freevideolectures.com

FINITE ELEMENT ANALYSIS	
MEC 415 (E)	**Credits : 3**
Instruction : 3 Periods & 1 Tut/Week	Sessional Marks : 40
End Exam : 3 Hours	End Exam Marks : 60

Prerequisites:

Mathematics, Mechanics, Strength of materials.

Course Objective:

To introduce students to the basics of FEM, other solution methods and derive the finite element equations for one dimensional and two dimensional elements. The objective is also to make students to apply FEM to structural and heat transfer problems.

Course Outcomes:

CO'S	CO DESCRIPTION
CO1	Analyze springs and bar problems using Rayleigh-Ritz and Galerkins methods, compare and contrast FEM with other analytical methods and explain the steps involved in FEM.
CO2	Analyze one dimensional bar problems using FEM.
CO3	Analyze plane truss and beam problems using FEM.
CO4	Analyze two dimensional structural problems using CST and Axi-symmetric elements.
CO5	Analyze one dimensional steady state problems in Heat transfer using FEM.

Mapping of course outcomes with program outcomes:

CO'S	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2				1			1	1		1	1	
CO2	2	2				1			1	1		1	2	
CO3	2	2				1			1	1		1	2	
CO4	2	2				1			1	1		1	2	
CO5	2	2				1			1	1		1	2	

SYLLABUS

Periods (L +T

UNIT-I:

FUNDAMENTAL CONCEPTS: (12+2)

Introduction, Historical Background, Stresses and Equilibrium, Boundary conditions, Strain-Displacement relations, Stress-strain relations, Compatibility conditions, Temperature effects, Plane stress and Plane strain conditions, Initial and Boundary value problems, Classification of boundary value problems, Types of boundary conditions.

Methods for solution of a general field problem-Potential energy method- Rayleigh-Ritz method-Galerkin method, Advantages of FEM over other methods, Steps involved in FEM, Engineering applications of FEM.

UNIT-II:

ONE-DIMENSIONAL PROBLEMS: (10+2)

Introduction, Finite Element Modeling, Coordinates and Shape Functions, Derivation of Element stiffness matrix and load vectors using Potential-Energy approach and Galerkin approach, Assembly of the Global Stiffness Matrix and Load Vector, Properties of Stiffness matrix, The Finite Element Equations; Treatment of Boundary conditions, Temperature effects- Problems.

UNIT-III

ANALYSIS OF TRUSSES: (10+2)

Trusses-Introduction-Derivation of element stiffness matrix-problems in Plane Trusses.

ANALYSIS OF BEAMS:

Beams-Introduction-Finite Element Formulation, Load vector, Boundary conditions, Shear force and bending moment.

UNIT-IV:

TWO-DIMENSIONAL PROBLEMS USING CST: (10 + 2)

Introduction-Finite Element Modelling-Constant-Strain Triangle (CST), Problem modelling and Boundary Conditions-Problems.

AXISYMMETRIC SOLIDS SUBJECTED TO AXISYMMETRIC LOADING:

Introduction-Axisymmetric Formulation-Finite Element Modelling: Trangular element, Problem Modelling and Boundary conditions-problems.

UNIT-V: **(8 + 2)**

SCALAR FIELD PROBLEMS:

Introduction-one dimensional steady state heat transfer in walls and fins, two dimensional steady state heat conduction, Convergence requirements.

TEXT BOOKS:

1. Tirupathi R. Chandrupatla, Ashok D.Belegundu *Introduction to Finite Elements in Engineering*, Fourth edition, Pearson education, 2011.
2. S.S.Rao *The Finite element method in engineering*, 5th edition, Elsevier publications, 2010.

REFERENCE BOOKS:

1. JN Reddy *An introduction to the Finite element method*, McGraw Hill Education; 3rd edition, 2005.
2. C.S. Krishnamoorthy Finite Element Analysis: Theory and Programming, Tata McGraw-Hill Education, 1995.
3. S.S. Bhavikatti *Finite element analysis*, New Age International, 2005.

WEB RESOURCES:

https://onlinecourses.nptel.ac.in/noc16_me02

http://www.open.edu/openlearn/science-maths-technology/introduction-finite-element-analysis/

REFRIGERATION AND AIR CONDITIONING	
MEC 416(A)	**Credits:3**
Instruction : 3periods & 1Tut/Week	Sessional Marks :40
End Exam : 3hrs	End Exam Marks: 60

Prerequisites:

Engineering Thermodynamics

Course Objectives:

To acquaint the student with different types of refrigeration systems working , their application and also to evaluate their performance.

Course Outcomes:

The student will be able to:

CO'S	CO DESCRIPTION
CO1	Compare the various refrigeration systems, their applications and further analyse aircraft refrigeration systems.
CO2	Analyse the working principles of Vapour Compression Refrigeration Systems (VCRS) and the methods of improving their performance.
CO3	Select appropriate refrigerant for a given application and further explain the working principles of Evaporators & Expansion devices.
CO4	Explain the functioning of vapour absorption refrigeration systems (VARS) and further compare VARS & VCRS.
CO5	Apply the Psychrometry principles for estimating the air-conditioning loads in various applications.

Mapping of Course Outcomes with Programme Outcomes.

High-3, Medium-2, Low-1

CO'S	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1			1						
CO2	1	2	1			1						
CO3	1		1			2	1	1				
CO4	1		1			1	1					
CO5	1	2	2			2						

SYLLABUS

Periods
(L +T)

UNIT-I **(10+2)**

Introduction and Gas cycle Refrigeration: Basic principles- Methods of Refrigeration- Joule Thomson coefficient-liquefaction of gases by linde's process -Unit of Refrigeration- Applications of Refrigeration.

Air cycle Refrigeration: Reversal Carnot cycle- Bell Coleman cycle- Air cycle systems for air craft refrigeration - Boot strap system- Regenerative cycle- Reduced ambient type- Comparisons of different systems.

UNIT-II **(10+2)**

Vapour Compression Refrigeration: Wet versus Dry compression- Effect of evaporator and condenser pressures. Liquid sub-cooling-superheating -Simple vapour compression Refrigeration cycle and its analysis. Actual VCRS- Methods of improving C.O.P.- Basics of multi pressure systems- Flash gas removal and Flash inter cooling- Defrosting- Hot gas defrosting.

UNIT-III **(10+2)**

Classification of Refrigerants: Nomenclature- Properties- Secondary refrigerants- Selection of refrigerants

Evaporators- Once through, flooded, shell and tube Baudelot cooler- **Expansion devices**- Automatic expansion valve ,Capillary expansion device, Thermostatic expansion device.

UNIT-IV **(10+2)**

Absorption Refrigeration System: Simple vapour absorption system-max C.O.P. of absorption refrigeration system - Common refrigerant-absorbent systems-Aqua ammonia absorption system-Li-Br absorption refrigeration system- Electrolux refrigeration- - Comparison of vapour compression andvapour absorption system.

Steam jet refrigeration system and analysis- Ejector compression system

UNIT-V **(10+2)**

Air conditioning: Fundamentals of psychrometry-Basic processes in conditioning of air-Sensible heat factor- By pass factor- Air washer-Water injection, Steam injection. Summer and Winter air conditioning systems- Different types of Air conditioning load -RSHF, GSHF- Fresh air quantity- Cooling coils and Dehumidity-Choice of inside design conditions-cold storage-industrial air conditioning-comfort air conditioning and effective temperature-comfort chart, salient features Human comfort

Text Books:

1. Refrigeration and Air conditioning, by C.P.Arora. 3Rd Edition , Tata Mc Graw Hil publishers ,2012
2. Refrigeration and Air conditioning, by P.L.Bellany. 6th edition , Khanna publishers,1983.

References:

1. Refrigeration and Air conditioning, by Jordan R.C. and Priester G.B. 2nd edn. Prentice-Hall, 1965
2. Principles of Refrigeration, by Dossat. 5th edition ,Pearson Education publisher ,2002.

Web Resources:

http://nptel.ac.in/downloads/112105129

nptel.ac.in/courses/Webcourse.../Ref%20and%20Air%20Cond/New_index1.html

COMPUTERIZED NUMERICAL CONTROL MACHINES & COMPUTER AIDED MANUFACTURING	
MEC 416(B)	**Credits : 3**
Instruction : 3 Periods & 1 Tut/Week	Sessional Marks : 40
End Exam : 3 Hours	End Exam Marks : 60

Prerequisites:

Manufacturing Technology – 1, Manufacturing Technology – 2, Manufacturing Technology - III

Course Objective:

This course makes the students understand the emergence and development of numerical control machine, characteristics and application areas. It familiarizes the components of computer aided manufacturing and computer aided process planning.

Course Outcomes:

By the end of the course, the student will be able to:	
1.	Explain about automated manufacturing system, elements and strategies of automation and its historical development and its future trends and further compare NC, CNC and DNC machines and explain their working.
2.	Describe the structural format of a manual part program and generate simple as well as complex part programs for CNC turning machine tools.
3.	Manually generate simple and complex manual part programs in CNC milling machine tools and also explain the hardware configuration of programmable logic controllers (PLC's).
4.	Describe the recent trends in CAM along with the concepts of Flexible manufacturing systems (FMS) and Computer integrated manufacturing (CIM).
5.	Explain the components of Group technology (GT) along with its applications in manufacturing processes and also describe the classifications of computer aided process planning (CAPP) techniques, computer aided quality control and its components and their importance as support systems in computer aided manufacturing (CAM).

Mapping of course outcomes with program outcomes:

		PO											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO	**1**		1	1	1						1		1
	2	2	1	3	2	2					1		1
	3	2	1	3	2	2					1		1
	4		1	1							1		1
	5			1	1					2	1		1

SYLLABUS **Periods (L+T)**

UNIT-I **(14+1)**

INTRODUCTION TO COMPUTER NUMERICAL CONTROL MACHINES

Introduction to Automation: Automated Manufacturing system; Need of automation, Basic Elements of automation, Levels of automation, Automation Strategies, Advantages & Disadvantages of automation, Historical development and future trends.

CAM - concept and definition: NC, CNC and DNC - concept, features and differences. Advantages and limitations of CNC, Selection criteria for CNC machines. CNC machines: Types, classification, working and constructional features. Elements of CNC machines - Types, working and importance of: Slide ways, Re-circulating ball screw, Feedback devices (transducers, encoders), Automatic tool changer (ATC), Automatic pallet changer (APC), CNC axes.

UNIT-II **(7+8)**

CNC TURNING MANUAL PART PROGRAMMING

Definition and importance of various positions like machine zero, home position, work piece zero and program zero, programming format and structure of part program.

ISO G and M codes for turning-meaning and applications of important codes.

Simple and Complex Manual part programming for turning using ISO format in straight turning, taper turning (linear interpolation) and convex/concave turning (circular interpolation), CNC Turning manual part programming using Canned cycles. Introduction to Automatic part programming.

UNIT-III **(7+8)**

CNC MILLING MANUAL PART PROGRAMMING

ISO G and M codes for milling-meaning and applications of important codes, Simple and Complex part programming for milling using ISO format - Importance, types, applications and format for: I. canned cycle's II. Macro III. Do loop IV. Subroutine

CNC turning and milling part programming using canned cycles, Do loops and Subroutine, Need and importance of various compensations: i. Tool length compensation. ii. Tool radius compensation. iii. Tool offset. Simple and Complex part programming using various compensations. Introduction to Automatic part programming.

UNIT-IV **(14+1)**

INTRODUCTION TO COMPUTER AIDED MANUFACTURING

Recent Trends in CAM :Interfacing standards for CAD/CAM - Types and applications, Adaptive control- definition, meaning, block diagram, sources of variability and applications. Flexible Manufacturing System (FMS) - concept, evaluation, main elements and their functions, layout and its importance, applications, Computer Integrated Manufacturing (CIM) - Concept, definition, areas covered, benefits.

UNIT-V

COMPUTER AIDED MANUFACTURING SUPPORT SYSTEMS ***(*****14+1)**

Introduction to GT, benefits, part families, part classification and coding, product flow analysis, cellular manufacturing, adaptation consideration in GT, quantitative analysis in cellular manufacturing, GT applications for manufacturing processes.

CAPP, benefits, types, forward and backward planning implementation considerations, process planning systems, CAQC (Computer aided quality control), JIT (Just in time) principles, MRP (Material requirements planning).

Text Books:

1. Pabla B.S., Adithan M.., "*CNC Machines*", New Age International, New Delhi, 2014 (reprint)
2. P.N. Rao, N. K. Tewari., "*Computer Aided Manufacturing*" Tata Mc Graw Hill Pub. New Delhi,2008.
3. Steve Krar and Arthar Gill, "*CNC Technology and Programming",* McGraw Hill Pub. Company, New Delhi, 1990.

Reference books:

1. Mikell P. Grover, "*Automation, Production Systems and Computer-Integrated Manufacturing*", Pearson Education, New Delhi.
2. P. Radha krishnan & S. Subramanyan, *"CAD/CAM/CIM",* Willey Eastern Limited New Delhi,2008.
3. Groover, M. P., Zimmer, W.E., "CAD/CAM: Computer Aided Design and Manufacturing", Prentice Hall, 2011.

Web resources:

1. http://nptel.ac.in/courses/112105211/
2. **http://nptel.ac.in/courses/112102103/**

AUTOMOBILE ENGINEERING	
MEC 416 (C)	**Credits : 3**
Instruction : 3 Periods & 1 Tut/Week	Sessional Marks : 40
End Exam : 3 Hours	End Exam Marks : 60

Prerequisites:

Theory of Machines-I, Material Science, Design of Machine Elements-II, Basic Electrical and Electronic Systems

Course Objective:

- To acquaint the students with the working of various automobile systems like engine, transmission, suspension, vehicle control, electrical and electronics.

Course Outcomes:

CO'S	CO DESCRIPTION
CO1	Categorize automobiles and describe the constructional features of engine parts.
CO2	Examine the operational features of various systems of engines used in an automobile.
CO3	Explain various transmission systems of an automobile.
CO4	Describe & distinguish various suspension systems, steering systems & brake systems of an automobile.
CO5	Illustrate the principles related to electrical and electronic systems used in an automobile.

Mapping of course outcomes with program outcomes:

CO'S	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1					1	1		1	1		1
CO2	1					1	1	1	1	1		1
CO3	1					1	1		1	1		1
CO4	1					1	1		1	1		1
CO5	1					1	1		1	1		1

SYLLABUS

Periods

(L +T)

UNIT-I **(9+1)**

Introduction:

Automobile - Definition, layout, classification; chassis, materials, Automobile body- parts, stream lining; construction details of engine components- cylinder block and crank case, cylinder, cylinder head, piston and piston rings, crank shaft, connecting rod, manifold and muffler.

UNIT-II **(13+1)**

Engine Systems:

Classification - based on arrangement of cylinders, Multi-Valve engines, VCR engines, Super Charging/Turbo charging; Air filters. Fuel Systems: Petrol Engines: Carburetted- Simple, S.U, Zenith, Solex, MPFI and SEFI, Ignition Systems- Conventional and Electronic. Diesel Engines: Conventional-Jerk type and distributor type; CRDI. Exhaust Emissions and their control: EGR and Catalytic Converters, EURO/Bharat Stage Norms: I, II, III, IV and V. Engine Cooling: Natural circulation and forced circulation. Lubrication: Mist, dry sump and wet sump.

UNIT-III **(15 + 1)**

Transmission System and Running System:

Clutch: Necessity, Construction and Working Principles of cone clutch, single & multi plate, centrifugal, CVT and Fluid coupling/Torque converter. Gearbox: Necessity of Transmission and Transaxle, Construction and Working Principle of Sliding mesh, Constant mesh- dog clutch, Synchromesh, Epicyclical and Automatic Gearbox. Drive Shaft: Constructional Features, Universal/Hooks Joints, Slip Joint, Types of Propeller shafts. Final drive and Differential: Necessity, Constructional Features and Working Principle of Open and LSD. Front/Rear Axles: Constructional Features and Types of Rear Axle Floating. Wheels: Disc and Drum type. Tires: Tire Construction, Tube and Tubeless Tires, Radial Tires, Tire specification, Tire rotation.

UNIT-IV **(11 + 1)**

Suspension System and Vehicle Control:

Suspension System: Types of suspension systems- MacPherson strut and Wishbone,Coil and Leaf Springs, Shock absorbers, Wheel alignment- Kingpin angle, Castor, Camber, Toe-in, and Toe-out. Vehicle Control: Steering system: Steering gear box and its types, Steering gear ratio, Constant Velocity Joints and linkages, Power Steering. Brake system: Necessity, Drum, Disc,

Parking and Power Brakes, Parts and Working Principle of Mechanical, Air and Hydraulic Brakes, Anti-lock Braking System.

UNIT-V **(7 + 1)**

Electrical and Electronic Systems:

Electrical system: Basics of Electrical/Electronic Systems: Battery, Starting system, Charging System, Lighting and Signalling System, A/C Electrical System. Electronic System: Electronic Engine Management system, Automotive Embedded Systems-Vehicle Security System and Working Principle of Computer Sensors: Temperature, Flow, Cam, knock, and Oxygen, coordination of sensors for engine processes.

Text Books:

1. Dr. Kirpal Singh, *Automobile Engineering Vol-I & II*, 12th edition, Standard Publishers, 2011.
2. William H. Crouse and Donald L. Anglin, *Automotive Mechanics*, 10th edition,Tata McGraw-HillPublishing Company Limited, 2006.
3. KK Jain & RB Asthana,*Automobile Engineering*, edition ,Tata McGraw-Hill Publishing Company Limited, 2002.

Reference Books:

1. S. Srinivasan, *Automotive Mechanics*, edition 2, Tata McGraw-Hill Publishingcompany Limited, 2003.
2. Joseph Heitner, *Automotive Mechanics (principles and practices*,2nd edition, East West press, 2006.
3. S Srinivasan,*Automotive Engines*, edition, Tata McGraw-Hill Publishing Company Limited, 2001.

Web Resources:

1. https://www.vidyarthiplus.com/vp/attachment.php?aid=42037
2. http://www.howdoesacarwork.com/p/1-engines_10.html

ENTREPRENEURSHIP DEVELOPMENT	
MEC 416(D)	**Credits:3**
Instruction : 3periods & 1Tut/Week	Sessional Marks :40
End Exam : 3hrs	End Exam Marks: 60

Prerequisite: Managerial economics and financial analysis, Industrial engineering and management

Course Objective:

To develop and strengthen entrepreneurial qualities in students by imparting basic entrepreneurial skills to run a business effectively and efficiently.

Course Outcomes:

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

CO-1	Exemplify the entrepreneurship concept and the qualities required for a successful entrepreneur.
CO-2	List the various supporting organizations for promoting entrepreneurship and the government policies.
CO-3	Prepare a feasibility report for a new business venture.
CO-4	Assess the requirements for small business ventures like finance and human resources.
CO-5	Comprehend the management techniques of small business and rehabilitation of business units.

Mapping of course outcomes with program outcomes :

		PO											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO	**1**	2	1	1	1	1		1		1		1	1
	2	3	3	3	2	1		1		1		1	1
	3	3	2	3	2	1		1		1		1	3
	4	2	3	2	1	1		1		1		1	1
	5	2	3	3	2	1		1		1		1	3

SYLLABUS (L+T)

UNIT I

ENTREPRENEURAL COMPETENCE: (10+2)

Entrepreneurship concept – Entrepreneurship as a Career – Entrepreneurial Personality - Characteristics of Successful Entrepreneur – Knowledge and Skills of Entrepreneur.

UNIT II

ENTREPRENEURAL ENVIRONMENT: (10+2)

Business Environment - Role of Family and Society - Entrepreneurship Development Training and Other Support Organisational Services - Central and State Government Industrial Policies and Regulations - International Business.

UNIT III

BUSINESS PLAN PREPARATION: (10+2)

Sources of Product for Business - Prefeasibility Study - Criteria for Selection of Product - Ownership - Capital - Budgeting Project Profile Preparation - Matching Entrepreneur with the Project - Feasibility Report Preparation and Evaluation Criteria.

UNIT IV

LAUNCHING OF SMALL BUSINESS: (10+2)

Finance and Human Resource Mobilization -Operations Planning - Market and Channel Selection - Growth Strategies - Product Launching – Incubation, Venture capital, IT startups.

UNIT V

MANAGEMENT OF SMALL BUSINESS: (10+2)

Monitoring and Evaluation of Business - Preventing Sickness and Rehabilitation of Business Units- Effective Management of small Business.

Text Books:

1. NVR Naidu& T. Krishna Rao, *"Management and Entrepreneurship*", I.K International Publishing House Pvt. Ltd, 2009.
2. Vasant Desai, *"Dynamics of Entrepreneurial Development & Management",* Himalaya Publishing House.

References: .

1. Poornima M. Charantimath, *"Entrepreneurship Development",* Small Business Enterprises Pearson Education 2006
2. S. S. Khanka "*Entrepreneurship Development",* S. Chand & Co,2013.
3. Stephen Robbins *"Management",* Pearson Education/PHI 17th Edition, 2003.

Online Reference: http://nptel.ac.in/courses.php

NANO TECHNOLOGY	
MEC 416 (E)	**Credits:3**
Instruction : 3periods & 1Tut/Week	Sessional Marks :40
End Exam : 3hrs	End Exam Marks: 60

Prerequisites: --- Engineering mathematics ,engineering physics,engineering chemistry and material science.

Course Objective

To acquaint the student on the basic scientific concepts of nanoscience, properties of nano materials, characterization of materials, synthesis , fabrication and also the applications of nano technology in various science, engineering and technology fields.

Course outcomes:

By the end of the course, the student will be able to:	
CO-1	Explain the essential basic concepts used in nanotechnology
CO-2	Analyze the nano materials with regards to their properties, synthesis and fabrication.
CO-3	Apply various characterization techniques used for evaluating the properties of nano materials.
CO-4	Analyze the characterization of carbon nano tubes.
CO-5	Comprehend the applications of nano technology to various fields

Mapping of course outcomes with program outcomes:

		PO											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO	**1**	1			1		1	1		1	1		1
	2	2	2	2	3		2	2		1		1	1
	3	2	1		2					1		1	1
	4	2	1	3	2		2	2		2	1	1	1
	5	1		2	1		3	2		2	1	2	1

SYLLABUS

Periods (L+T)

UNIT-I **(11+1)**

INTRODUCTION: History of nano science, definition of nanometer, nano materials, nano technology. Classification of nano materials. Crystal symmetries, crystal directions, crystal planes, Band structure.

PROPERTIES OF MATERIALS:

Mechanical properties, electrical properties, dielectric properties, thermal properties, magnetic properties, opto electronic properties. Effect of size reduction on properties, electronic structure of nano materials.

UNIT-II

SYNTHESIS AND FABRICATION: **(11+1)**

Synthesis of bulk polycrystalline samples, growth of single crystals. Synthesis techniques for preparation of nano particle - Bottom Up Approach - sol gel synthesis, hydro thermal growth, thin film growth, PVD and CVD; Top Down Approach - Ball milling, micro fabrication, lithography. Requirements for realizing semiconductor nano structures, growth techniques for nano structures.

UNIT-III

CHARACTERIZATION TECHNIQUES: **(11+1)**

X-Ray diffraction and Scherer method, scanning electron microscopy, transmission electron microscopy, scanning probe microscopy, atomic force microscopy, Raman spectroscopy.

UNIT-IV

CARBON NANO TECHNOLOGY: **(11+1)**

Characterization of carbon allotropes, synthesis of diamond - nucleation of diamond, growth and morphology. Applications of nano crystalline diamond films, graphene, applications of carbon nano tubes.

UNIT-V

APPLICATIONS OF NANO TECHNOLOGY: **(14+1)**

Applications in material science, biology and medicine, surface science, energy and environment. Applications of nano structured thin fins, applications of quantum dots.

TEXT BOOKS:

1. Nano science and nano technology by M.S Ramachandra Rao, Shubra Singh, Wiley publishers, Year: 2013.

2. Introduction to Nanoscience and Nanotechnology by K.K.A.N. Banerjee Chattopadhyay, A. N. Banerjee, Year: Feb 23, 2007.

3. Introduction To Nanoelectronics: Science, Nanotechnology, Engineering, And Applications Vladimir V. Mitin, Viatcheslav A. Kochelap, Michael A. Stroscio , Year : 2010.

REFERENCE BOOKS:

1. Introduction to Nano Technology by Charles P. Poole, Jr., Frank J.Owens, Wiley publishers, Apr 16, 2004.

2. Nanotechnology by Jermy J Ramsden, Elsevier publishers, Sep 19, 2012.

3. Nano Materials- A.K.Bandyopadhyay/ New Age International Publishers, Year : 2007.

4. Nano Essentials- T.Pradeep/TMH, Jan 20, 2007.

5. Nanotechnology the Science of Small by M.A Shah, K.A Shah, Wiley Publishers, Year : 2013.

6. Principles of Nanotechnology by Phani Kumar, Scitech, Year : 2010.

Web Resources:

http://www.nptel.ac.in

http://www.freevideolectures.com

HEAT TRANSFER LABORATORY	
MEC 417	**Credits : 2**
Instruction : 3 Periods	Sessional Marks : 50
End Exam : 3 Hours	End Exam Marks : 50

Pre-Requisite: Engineering Thermodynamics-I, Fluid Mechanics, Heat transfer

Course Objective:

To demonstrate the principles of conduction, convection and radiation.

Course Outcomes:

CO'S	CO DESCRIPTION
CO1	Determine the thermal conductivity of a given insulating powder/a given metal by experimentation.
CO2	Determine the heat transfer coefficient of air in free and forced convection by experimentation and compare these with theoretical values.
CO3	Conduct experiment in unsteady heat transfer to verify lumped system analysis.
CO4	Experimentally determine the Stefan-Boltzmann constant and emissivity of a grey body.

Mapping of Course Outcomes with Programme Outcomes.

High-3, Medium-2, Low-1

CO'S	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**1**	**1**		**1**				**1**		**1**		**1**
CO2	**1**	**2**		**1**				**1**		**1**		**1**
CO3	**2**	**2**		**2**				**1**		**1**		**1**
CO4	**1**	**1**		**1**				**1**		**1**		**1**

List of Experiments:

1) Determination of thermal conductivity of asbestos powder at different heat inputs in hollow sphere.
2) Determination of thermal conductivity of glass wool at different heat inputs incomposite cylinder.
3) Determination of thermal conductivity of metal rod (Brass).

4) Determination of overall heat transfer coefficient of composite wall.
5) Determination of convective heat transfer coefficient of vertical cylinder in free convection.
6) Determination of convective heat transfer coefficient of horizontal pipe in forced convection.
7) Determination of Stefan Boltzman constant.
8) Determination of Emissivity of Grey body.
9) Determination of fin effectiveness and efficiency under forced convection.
10) Determination of time interval in different mediums under unsteady state heattransfer.
11) Determination of condensation coefficient in film and drop wise condensation.
12) Determination of overall heat transfer coefficient of double pipe heat exchanger.

Data Book:

1. Heat and Mass Transfer Data Book , C.P.Kothandaraman , S. Subramaniam, 8^{th} Edition, New Age International Publishers Limited.

E-Resources : www.physicsclassroom.com , www.biocab.org/Heat_Transfer.html

COMPUTER AIDED DESIGN LAB	
MEC418	**Credits:2**
Instruction : 3periods /Week	Sessional Marks :50
End Exam : 3hrs	End Exam Marks: 50

Objectives

To train the students in using the drafting, modelling and analysis softwares in mechanical engineering applications like preparing 2D and 3D drawings, structural analysis, thermal analysis and modal analysis of components and further acquaint the students with CNC programming and ROBO programming.

Course outcomes:

CO'S	CO DESCRIPTION
CO1	Draw two dimensional views of any mechanical component using Auto CAD software.
CO2	Create three dimensional part models and assemblies of machine components using Solidworks software.
CO3	Evaluate the stresses in 2D beams and trusses in static conditions using ANSYS software.
CO4	Determine the stresses in 3D Components using Solidworks software.
CO5	Develop and execute programs for CNC Machine, further perform material handling operation using “Pick and Place” ROBOT.

Mapping of course outcomes with program outcomes:

CO'S	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1		1		3			1		1		1
CO2	1		2		3			1		1		1
CO3	1	2	2		3			1		1		1
CO4	1	2	2		3			1		1		1
CO5	1		1		2			1		1		1

CAD experiments:

1. Drawing the orthographic views of cotter joint using AutoCAD
2. Drawing the orthographic views of knuckle joint using AutoCAD
3. Preparing Part model, Assembly and drawing of Oldham coupling
4. Preparing Part model, Assembly and drawing of Universal coupling
5. Preparing Part model, Assembly and drawing of Screw Jack
6. Static analysis of beam using ANSYS
7. Static analysis of Truss using ANSYS
8. To evaluate the temperature distribution and the heat loss from a fin subjected to temperature boundary conditions.
9. Evaluating the mode shapes and frequencies of a cantilever beam.

CAM experiments:

1. Preparation of manual part programming for CNC turning/Milling.
2. Machining of one job on CNC machine tool.
3. Robot programming through computer.

Industrial Training	
MEC 419	**Credits:2**
Instruction : -	Sessional Marks :100
End Exam : Viva-voce	End Exam Marks:-

The curriculum is designed to include industrial training so that the student is given an exposure to industry for a period extending from 2 – 3 weeks at the end of third year. The student should go through a training programme in any local industry / workshop. The training programme is decided by the industry people so that the student gets a practical understanding of the industrial processes. At the end of the programme the student should submit a comprehensive report to the department.

The evaluation of the industrial training for the award of grade is done in the final year 1st semester and is based on internal Viva – voce examination.

The project is divided into two phases. The phase-I is done in final year first semester followed by the phase-II which is executed in the second semester.

PROJECT (PHASE-1)	
MEC 420	**Credits:4**
Instruction : 5 Practicals	Sessional Marks :100
End Exam : Viva-voce	End Exam Marks: -

In the first phase, the student is exposed to the requirements to be met in the project. The student is given an opportunity to decide the area of work based on his interest. Once the area of work is decided, the student is required to do literature review and summarize the findings. Based on the review, the student and the guide are supposed to finalize the problem and chart out the procedure for executing the project work.

For an analytical work, the governing equations should be developed and the mathematical techniques to be used in solving them should also be completed.

For an experimental based project, the setting up of experimentation, materials & accessories procurement should be completed.

For an Analysis project which is based on software tools, modelling should have been completed.

For fabrication of a model, the basic design & development of the model and procurement of accessories should be completed.

The evaluation of Phase-I of the project work is based on an internal Viva-voce examination which is conducted twice. The first evaluation is done in the mid of the semester followed by the final evaluation at the end of the semester. The student has to submit a report.

INSTRUMENTATION & CONTROL SYSTEMS	
MEC 421	**Credits:3**
Instruction : 3 Periods & 1 Tutorial /Week	Sessional Marks :40
End Exam : 3hrs	End Exam Marks: 60

Prerequisites:

Engineering Physics and Applied Physics

Course objective:

The course focuses on imparting the principles of measurement which includes the working mechanism of various transducers and devices that are in use to measure the important physical variables and also to introduce the basics of control systems and PLC. **[**

Course outcomes:

CO'S	CO DESCRIPTION
CO1	Explain the basic principles & performance characteristics of measurement and also select a suitable displacement measuring instrument for a given application/experimentation.
CO2	Explain the basic principles, working, advantages, disadvantages and applications of temperature and pressure measuring devices and select a suitable pressure & temperature measuring instrument for a given application/experimentation.
CO3	Comprehend the basic principles, working, advantages, disadvantages and applications of level, flow, speed, acceleration and vibration measuring instruments and also select a suitable instrument for a given application/experimentation.
CO4	Describe the basic principles, working, advantages, disadvantages and applications of stress strain, humidity, force, torque and power measuring instruments and also select a suitable instrument for a given application/experimentation.
CO5	Explain the basic principles, working, advantages, disadvantages and applications of various control systems for measuring instruments.

Mapping of course outcomes with program outcomes:

CO'S	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1		1					1	1		1		1
CO2	1	1		1					1	1		1		1
CO3	1	1		1					1	1		1		1
CO4	1	1		1					1	1		1		1
CO5	1								1	1		1		1

SYLLABUS **Periods (L+T)**

UNIT-I **(8+2)**

Introduction: Basic principles of measurement – measurement systems, generalized configuration and functional descriptions of measuring instruments – examples. Static and Dynamic performance characteristics – sources of error, classification and elimination of error, calibration procedures.

Measurement of Displacement: Theory and construction of various transducers to measure displacement – piezo-electric, inductive, capacitance, resistance, ionization and photo electric transducers.

UNIT-II **(10+2)**

Measurement of Temperature: Classification – ranges – various principles of measurement – expansion, electrical resistance – thermistor – thermocouple – pyrometers.

Measurement of Pressure: Units – classification – different principles used. Manometers, piston, bourdon pressure gauges, bellows – diaphragm gauges. Low pressure measurement – thermal conductivity gauges – ionization pressure gauges, McLeod pressure gauge.

UNIT-III **(10+2)**

Measurement of Level: Direct method – indirect methods – capacitative, ultrasonic, magnetic, cryogenic fuel level indicators – bubbler level indicators.

Flow Measurement: Rotameter, magnetic, ultrasonic, turbine flow meter, hot – wire anemometer, Laser Doppler Anemometer (LDA).

Measurement of Speed: Mechanical tachometers – electrical tachometers – stroboscope

Measurement of Acceleration And Vibration: Different simple instruments – principles of seismic instruments – vibrometer and accelerometer using this principle.

UNIT-IV **(10+2)**

Measurement of Force, and Torque - Elastic force meters, load cells, torsion meters, dynamometers.

Stress - Strain Measurements: Various types of stress and strain measurements – electrical strain gauge – gauge factor – method of usage of resistance strain gauge for bending, compressive and tensile strains – usage for measuring torque, strain gauge rosettes.

UNIT-V **(10+4)**

Elements of Control Systems: Introduction, importance – classification – open and closed systems, servomechanisms–examples with block diagrams–temperature, speed & position control systems.

Text Books:

1. A.K.Sawheny, "*Mechanical Measurements and Instrumentation",3rd edition,* Dhanpat Rai, 2004.
2. I.J. Nagrath & M.Gopal, "*Control Systems Engineering"*, New age international, 4th edition, 2006.

Reference Books:

1. D.S.Kumar, *"Measurement Systems: Applications & design",* 6th edition, Metropolitan, 2002.
2. J.P.Holman, *"Experimental Methods for Engineers"*, 7th edition McGraw-Hill, 2010.
3. A.K.Tayal & Akash Tayal, *"Instrumentation, Mechanical Measurements and Control"*, 2nd Edition, Galgotia Publications Pvt Ltd, 1999.

Web resources:

https://www.youtube.com/watch?v=DHjpkPoUk4I

https://www.youtube.com/watch?v=g1kb-hn_if4

https://www.youtube.com/watch?v=y9B0NqNF11I

NON-CONVENTIONAL ENERGY SOURCES	
MEC 422 (A)	**Credits:3**
Instruction : 3periods & 1Tut/Week	Sessional Marks :40
End Exam : 3hrs	End Exam Marks: 60

Prerequisites:

Engineering mathematics, Engineering mechanics, Thermodynamics.

Course Objectives:

In the backdrop of depleting fossil fuels, the course is intended to give a overall perspective of the potential of non-conventional energy sources like solar, wind, ocean, geothermal etc. The course also attempts to stress the importance of direct energy conversion systems.

Course Outcomes:

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

CO'S	CO DESCRIPTION
CO1	Distinguish various renewable energy sources & calculate solar variables by applying the principles of solar radiation
CO2	Classify solar collectors, solar storage systems & explain the various solar photovoltaic systems
CO3	Evaluate the performance characteristics of wind generators and classify the bio-gas plants.
CO4	Elucidate the working principles of OTEC, tidal power generation & geothermal power plants.
CO5	Illustrate the principle and importance of Direct energy conversion devices (MHD & Fuel cells).

Mapping of Course Outcomes with Programme Outcomes.

High-3, Medium-2, Low-1

CO'S	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**1**	**1**				**1**	**1**		**1**	**1**		**1**
CO2	**1**	**1**				**1**	**1**		**1**	**1**		**1**
CO3	**1**	**1**				**1**	**1**		**1**	**1**		**1**
CO4	**1**	**1**				**1**	**1**		**1**	**1**		**1**
CO5	**1**	**1**				**1**	**1**		**1**	**1**		**1**

Syllabus

(L+T)

UNIT – I **(8+2)**

Introduction to Non conventional energy resources: India's production and reserves of commercial energy sources, need for non-conventional energy sources, energy alternatives, solar, thermal, photovoltaic. Water power, wind biomass, ocean temperature difference, tidal and waves, geothermal.

Principles of solar radiation : Solar constant, extraterrestrial and terrestrial solar radiation, direct & diffuse radiation, solar geometry, solar radiation data, solar radiation on titled surface, solar radiation measurement.

UNIT-II **(10+4)**

Solar Thermal Systems Types of solar collectors-non-concentric & concentric type, flat plate collectors-performance analysis, Absorber coatings. Solar energy storage systems-types & Applications.

Solar Photovoltaic Systems Operating principles. Photovoltaic cell concepts. Cell, module, array. Series and parallel connections. Applications.

UNIT-III **(10+4)**

Wind energy: Wind patterns and wind data. Site selection. Wind power calculations, Performance Characteristics of wind generators. Compenents and classifications of WEC systems.

Bio-mass : Operating principles. Conversion and fermentation-wet and dry processes. Photosynthesis, Bio-gas generation-Anaerobic digestion, classification of bio-gas plant.

UNIT-IV **(10+2)**

Geothermal energy: Geothermal sources-classification-vapour, liquid dominating systems, applications..

Ocean energy: Ocean Thermal Energy Conversion (OTEC)-principles and thermodynamic cycles. Energy of tides: introduction, principles, components, operation methods, limitations of tidal power generation. wave energy conversion techniques.

UNIT-V **(10+2)**

Direct energy conversion: Principles of DEC, Thermo-electric generators, seebeck, peltier and joule Thomson effects, Selection of materials, applications.

Magneto Hydro dynamic generators (MHD): principles, dissociation and ionization, Thermal efficiency, MHD Engine, power generation systems.

Fuel cells: Design &principle of operation, classification, types of fuels, efficiency.

TEXT BOOKS

1. G.D. Rai, *"Non-Conventional Energy Sources"*, Khanna publishers, 2004
2. Tiwari and Ghosal, *"Renewable energy resources"*, Narosa publications, 2004

REFERENCES

1. Twidell & Weir, Taylor & Francis *"Renewable Energy Sources"*, 2006
2. Sukhatme *"Solar Energy"*, Tata McGraw-Hill Education, 1996
3. Frank Krieth & John F Kreider *"Principles of Solar Energy"*.
4. Ashok V Desai *"Non-Conventional Energy",* Wiley Eastern publications,
5. John Twideu and Tony Weir *"Renewal Energy Resources"*, BSP Publications, 2006.

Web resources:

1. http://nptel.ac.in/courses/112101098
2. http://nptel.ac.in/courses/121106014/
3. http://nptel.ac.in/courses.php

CONDITION MONITORING	
MEC 422 (B)	**Credits:3**
Instruction : 3periods & 1Tut/Week	Sessional Marks :40
End Exam : 3hrs	End Exam Marks: 60

Prerequisites:

Engineering mechanics, Theory of machines, Instrumentation and control systems.

Course objective:

To familiarize the students with different types and causes of failure of mechanical components and different condition monitoring techniques available for reactive, preventive & predictive maintenance types.

Course outcomes:

By the end of the course, the student will be able to:	
CO-1	Interpret various types of mechanical failures and different maintenance techniques.
CO-2	Comprehend diverse condition monitoring techniques and fault detection sensors.
CO-3	Explain and predict the causes of vibrations by using vibration monitoring techniques.
CO-4	Describe and analyze the wear debris monitoring methods.
CO-5	Apply thermography as a tool for condition monitoring and further explain the intricacies of it.

Mapping of course outcomes with program outcomes:

		PO												**PSO**	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO	**1**		2	1	2					2	2	1	1	1	
	2		2	1	2					2	2	1	2	1	
	3	1	2	1	2	3				2	2	1	2	2	1
	4	2	2	2	2					2	1	1	2	1	1
	5	2	2	2	2	2				2	1	1	2	1	

SYLLABUS **Periods**

(L+T)

UNIT-I **(12+1)**

Introduction about condition monitoring: Failures, Types of failures, Causes of failures, Bath tub curve, Maintenance types- Reactive, Preventive, Predictive and Proactive maintenances

UNIT-II **(14+1)**

Condition monitoring techniques: Visual monitoring, Thermography, Vibration monitoring, Shock pulse monitoring, Wear debris monitoring, Motor current signature analysis, Acoustic emission, Ultrasound monitoring, ISO standards, fault detection sensors**.**

UNIT-III **(15+2)**

Vibration monitoring: Definition, principles of vibration monitoring, causes of vibration- unbalance, misalignment, bent shaft, oil whirl, anti-friction bearings, mechanical looseness, gear problems, vibration transducer, vibration analyzer, vibration software- simple case study.

UNIT-IV **(14+1)**

Wear debris monitoring: Introduction, Types of wear, benefits of wear debris analysis, detection of wear particles – Spectroscopy, Ferrography, Particle count, common wear materials, oil sampling technique, oil analysis, limits of oil analysis

UNIT-V **(14+1)**

Thermography: Introduction, thermograms, thermal imaging devices- Optical pyrometer , Infrared cameras, use of IR camera , industrial applications of thermography - leakage detection, machineries, advantages, disadvantages and applications of thermography in condition monitoring with a case study.

Text Books:

1. Amiya R.Mohanty *Machinery condition monitoring: Principles and Practices* , CRC Press publisher (2015)
2. R.A. Collacott *Mechanical Fault Diagnosis and condition monitoring,* Springer Netherlands Publisher

Reference Books:

1. Cornelius scheffer, Paresh Girdhar *Practical Machinery vibration analysis and Predictive Maintenance* , Newnes(Elsevier)
2. Alan Davies, *Hand book of condition monitoring techniques and Methodology* , Chapman and Hall Publisher

3. J.S.Rao, *Vibratory condition monitoring of Machines*, Narosa Publishing House

Web resources:

1. https://www.youtube.com/watch?v=VbytRqnQ6kI
2. http://nptel.ac.in/courses/112103112/40
3. nptel.ac.in/courses/112105048/36
4. https://www.youtube.com/watch?v=JlD-Uec7Zmk
5. http://nptel.ac.in/courses/112105048/33

COMPUTATIONAL FLUID DYNAMICS	
MEC 422 (C)	**Credits : 3**
Instruction : 3 Periods & 1 Tut/Week	Sessional Marks : 40
End Exam : 3 Hours	End Exam Marks : 60

Prerequisites: Mathematics, Fluid Mechanics and Heat Transfer

Course Objectives:

To impart the knowledge of numerical techniques to the solution of fluid dynamics and heat transfer problems.

Course Outcomes:

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

CO-1	Formulate Governing Equations of fluid dynamics and analyze their mathematical behavior.
CO-2	Apply the Finite Difference and Finite volume methods for solving simple one, two and threedimensional diffusion problems.
CO-3	Apply Finite volume method for solving steady one dimensional convection-diffusion problems.
CO-4	Apply Finite volume method for flow field analysis.
CO-5	Explain the various turbulence models and mesh generation techniques.

Mapping of Course Outcomes with Programme Outcomes. High-3, Medium-2, Low-1

COURSE OUTCOMES	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**2**		**1**		**2**	**3**	**2**		**1**	**1**	**1**
CO2	**2**	**3**	**1**	**2**		**2**	**2**			**1**	**1**	**2**
CO3	**2**	**3**	**2**	**1**	**1**	**1**	**2**	**3**		**3**	**1**	**1**
CO4	**2**	**2**	**1**	**1**		**2**	**3**	**1**		**2**	**1**	**1**
CO5	**2**	**2**	**1**	**1**	**2**	**2**	**2**	**1**		**1**	**1**	**1**

SYLLABUS

Periods (L +T)

UNIT I **(10+2)**

GOVERNING EQUATIONS AND BOUNDARY CONDITIONS

Basics of computational fluid dynamics – Governing equations of fluid dynamics – Continuity, Momentum and Energy equations – Chemical species transport – Physical boundary conditions – Time-averaged equations for Turbulent Flow – Turbulent–Kinetic Energy Equations – Mathematical behavior of PDEs on CFD - Elliptic, Parabolic and Hyperbolic equations**.**

UNIT II

FINITE DIFFERENCE AND FINITE VOLUME METHODS FOR DIFFUSION (10+2)

Derivation of finite difference equations – Simple Methods – General Methods for first and second order accuracy – Finite volume formulation for steady state One, Two and Three - dimensional diffusion problems –Parabolic equations – Explicit and Implicit schemes – Example problems on elliptic and parabolic equations – Use of Finite Difference and Finite Volume methods**.**

UNIT III

FINITE VOLUME METHOD FOR CONVECTION AND DIFFUSION (10+2)

Steady one-dimensional convection and diffusion – Central, upwind differencing schemes properties of discretization schemes – Conservativeness, Boundedness, Transportiveness, Hybrid, Power-law, QUICK Schemes.

UNIT IV

FLOW FIELD ANALYSIS (10+2)

Finite volume methods -Representation of the pressure gradient term and continuity equation – Staggered grid – Momentum equations – Pressure and Velocity corrections – Pressure Correction equation, SIMPLE algorithm and its variants – PISO Algorithms.

UNIT V

TURBULENCE MODELS AND MESH GENERATION (10+2)

Turbulence models, mixing length model, Two equation (k-Є) models – High and low Reynolds number models – Structured Grid generation – Unstructured Grid generation – Mesh refinement – Adaptive mesh – Software tools.

TEXT BOOKS:

1. Versteeg, H.K., and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The finite volume Method", Pearson Education Ltd.Second Edition – 2007.

2. Ghoshdastidar, P.S., "Computer Simulation of flow and heat transfer", Tata McGraw Hill Publishing Company Ltd., 1998.

REFERENCES:

1. Patankar, S.V. "Numerical Heat Transfer and Fluid Flow", Hemisphere Publishing Corporation, 2004.

2. Chung, T.J., "Computational Fluid Dynamics", Cambridge University, Press, 2002.

3. Ghoshdastidar P.S., "Heat Transfer", Oxford University Press, 2005

4. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 1995.

5. ProdipNiyogi, Chakrabarty, S.K., Laha, M.K. "Introduction to Computational Fluid Dynamics", Pearson Education, 2005. 6. Anil W. Date, "Introduction to Computational Fluid Dynamics", Cambridge University Press, 2005.

Web Resources:

http://nptel.ac.in/courses/112105045/

STATISTICAL QUALITY CONTROL	
MEC 422(D)	**Credits:**
Instruction : 3periods & 1Tut/Week	Sessional Marks :40
End Exam : 3hrs	End Exam Marks: 60

Prerequisites: ---

Course objectives: To acquaint the students with the basic knowledge of statistical quality control and explain the construction of control charts for variables and attributes. To analyze performance of the control charts and capability of a process. To instruct acceptance sampling plans and use of Dodge-Romig tables.

Course outcomes:

By the end of the course, the student will be able to:	
CO-1	Comprehend the basic knowledge of statistical quality control such as definitions of quality, off-line and on-line quality control techniques, Deming's philosophy, qualitycosts, Taguchi's loss function and six sigma concepts.
CO-2	Produce the control charts for variables, analyze their performance and can evaluateprocess performance.
CO-3	Analyze and make conclusions about the process capability.
CO-4	Use the control charts for attributes and can conclude about the process control.
CO-5	Design, apply and analyze the sampling plans and will be able to judge the quality of theproducts or the process that produces the products.

Mapping of course outcomes with program outcomes:

		PO												**PSO**	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO	**1**	2	2	3	3	2	3	3	1	3	2	3	3	2	2
	2	3	3	3	3	3	3	3	1	3	2	3	3	3	3
	3	3	3	3	3	3	3	3	1	3	2	3	3	3	3
	4	3	3	3	3	3	3	3	1	3	2	3	3	3	3
	5	3	3	3	3	3	3	3	1	3	2	3	3	3	3

SYLLABUS **Periods (L+T)**

UNIT-I **(11+1)**

Introduction to quality: Definitions and dimensions of quality; Deming's quality philosophy; Quality costs; Examples of off-line and on-line quality control techniques; Taguchi's loss function; Introduction to six sigma concept.

UNIT-II **(10+4)**

Control charts for variables: Shewhart's normal bowl; $\bar{x}$, R and σ control charts; Type-I and Type- II errors; Theory of runs - ARL and ATS.

UNIT-III **(5+1)**

Process capability analysis: Process capability analysis using frequency distribution; Process capability analysis using control charts; Process capability analysis using process capability ratios - C_p and C_{pk}; Process capability ratios for nominal the better type, smaller the better type and larger the better type product specifications.

UNIT-IV **(10+4)**

Control charts for attributes: p chart, standardized p chart, np chart, c chart, u chart, ku chart, and demerit control chart.

UNIT-V **(10+4)**

Acceptance sampling plans: Single, double, multiple and sequential sampling plans; Design of single and sequential sampling plans; Rectifying inspection - AOQ, AOQL, and ATI; Use of Dodge Romig tables.

Text Books:

1. A. Mitra, "*Fundamentals of Quality Control and Improvement",* John Wiley,2008.
2. M. Mahajan, "*Statistical Quality Control",* Dhanpatrai & Co, 2016.

Reference Books:

1. D. C. Montgomery, *"Introduction to Statistical Quality Control"*, John Wiley & sons, 2009.
2. E.L. Grant, *" Introduction to Statistical Quality Control",* Tata Mc-Graw Hill Co. Ltd, 2000.

Web Resources:

1. http://www.nptel.ac.in
2. http://www.freevideolectures.com

MECHATRONICS	
MEC 422 (E)	**Credits:3**
Instruction : 3periods & 1Tut/Week	Sessional Marks :40
End Exam : 3hrs	End Exam Marks: 60

Prerequisites:

Engineering mechanics, Basic Electronics.

Course objective:

To familiarize the students the importance of industrial automation and various modelling and simulation techniques. Further introduce them to the application of electronics and electrical principles to mechanical systems.

Course outcomes:

By the end of the course, the student will be able to:	
CO-1	Explain mechatronics key elements, advanced approaches in mechatronics & mechatronics design process.
CO-2	Develop the block diagrams of various electro mechanical systems.
CO-3	Explain the working of different types of sensors and transducers
CO-4	Explain the installation procedure of I/O card and software.
CO-5	Compare and contrast the applications of sensors in mechatronics systems.

Mapping of course outcomes with program outcomes:

	PO											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO 1							1		1	1	2	
CO 2							1		1	1	2	
CO 3				1			1		1	1	2	
CO 4	2						1		1	1	2	
CO5			2	1			1		1	1	2	

SYLLABUS **Periods**

(L+T)

UNIT-I **(5+1)**

Introduction to Mechatronics:

Integrated design issues in mechatronics, Mechatronics key elements, the mechatronics design process, advanced approaches in mechatronics.

UNIT-II **(8+4)**

Modeling and simulation of physical systems:

Simulation and block diagrams, Analogies and impedance diagrams, Electrical systems, Mechanical translational systems, Mechanical rotational systems, electromechanical coupling, Fluid systems.

UNIT-III

Sensors and transducers: **(12+4)**

An introduction to sensors and transducers, Sensors for motion and position measurement, Force, torque and tactile sensors, Flow sensors, Temperature sensing devices. Actuating devices: Direct current motor, Permanent magnet stepper motor, Fluid power actuation.

UNIT-IV **(8+4)**

Real time interfacing:

Introduction, Elements of a data acquisition and control system, Overview of the I/O process, Installation of the I/O card and software.

UNIT-V **(10+4)**

Advanced applications in mechatronics:

Sensors for condition monitoring, Mechatronic control in automated manufacturing, Artificial intelligence in mechatronics, Microsensors in mechatronics.

Text Books:

1. Devdasshetty, Richard A. Kolk, “Mechatronics System Design”, 2nd Edition ,Cengage Learning 2011.
2. Georg pelz, "Mechatronic Systems: Modeling and simulation" with HDL’s, John wiley and sons Ltd, 2003

Reference Books:

1. Bishop, Robert H, "Mechatronics Hand book", CRC Press, 2002.
2. Bradley, D.Dawson, N.C. Burd and A.J. Loader, "Mechatronics: Electronics in Products and Processes", CRC Press 1991 , First Indian print 2010.
3. De Silva, "Mechatronics: A Foundation Course", Taylor & Francis, Indian Reprint, 2013

Web resources:

1. http://nptel.ac.in/downloads/112103174/

PROJECT (PHASE-II)	
MEC 423	**Credits:8**
Instruction : 12 Practical	Sessional Marks :100
End Exam : Viva-voce	End Exam Marks:100

In the second phase of the project work, the student should continue the work from the stage where he has left in the phase-I and complete it.

The evaluation of Phase-II of the project work is based on both internal and external examination. The internal evaluation is done in the mid and also at the end of the semester, Where in the student has to give a PowerPoint presentation followed by Viva – voce.

The external examination is also based on similar lines in the presence of both internal and external examiners.

MOOCs	
MEC 424	**Credits:2**
Instruction : -	Sessional Marks :100
End Exam : Viva-voce	End Exam Marks:-

A student can also opt for MOOCS{Massive online open courses} at any time during the IV Year B. Tech course in any of the courses offered by Premium institutions such NPTEL, MIT, Stanford etc., and have to provide course completion certificate for award of credits. Marks are evaluated by a departmental committee in IV year- II Semester as follows:

50% Marks are awarded for certificate.
50% Marks are awarded for internal Viva-voce.

The total marks are then considered for the final grading.