VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2015-2016

VII SEMESTER **B.E. Mechanical Engineering**

Sl. No	Subject Code	Title	Teaching Hours /Week			Examination				Credits
			Lecture	Tutorial	Practical	Duration (Hours)	Theory/ Practical Marks	I.A. Marks	Total Marks	
1	15ME71	Energy Engineering	3	2	0	03	80	20	100	4
2	15ME72	Fluid Power Systems	4	0	0	03	80	20	100	4
3	15ME73	Control Engineering	3	2	0	03	80	20	100	4
4	15ME74X	Professional Elective - III	3	0	0	03	80	20	100	3
5	15ME75X	Professional Elective-IV	3	0	0	03	80	20	100	3
6	15MEL76	Design Lab	1	0	2	03	80	20	100	2
7	15MEL77	CIM Lab	1	0	2	03	80	20	100	2
8	15MEP78	Project Phase – I	-	-	-	-	-	100	100	2
		TOTAL	**18**	**4**	**04**		**560**	**240**	**800**	**24**

Professional Elective-III		Professional Elective-IV	
15ME741	Design of Thermal Equipments	15ME751	Automotive Electronics
15ME742	Tribology	15ME752	Fracture Mechanics
15ME743	Financial Management	15ME753	Mechatronics
15ME744	Design for Manufacturing	15ME754	Advanced Vibrations
15ME745	Smart Materials & MEMS		

1. **Core subject:** This is the course, which is to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in a said discipline of study.
2. **Professional Elective:** Elective relevant to chosen specialization/ branch

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VIII SEMESTER **B.E. Mechanical Engineering**

Sl. No	Subject Code	Title	Teaching Hours /Week			Examination				Credits
			Lecture	Tutorial	Practical	Duration (Hours)	Theory/ Practical Marks	I.A. Marks	Total Marks	
1	15ME81	Operations Research	3	2	0	03	80	20	100	4
2	15ME82	Additive Manufacturing	4	0	0	03	80	20	100	4
3	15ME83X	Professional Elective - V	3	0	0	03	80	20	100	3
4	15ME84	Internship / Professional Practice	Industry Oriented			03	50	50	100	2
5	15ME85	Project Phase – II	-	6	-	03	100	100	200	6
6	15MES86	Seminar	-	4	-	-	-	100	100	1
TOTAL			**10**	**12**	**-**		**390**	**310**	**700**	**20**

Professional Elective-V	
15ME831	Cryogenics
15ME832	Experimental Stress Analysis
15ME833	Theory of Plasticity
15ME834	Green Manufacturing
15ME835	Product life cycle management

1. **Core subject:** This is the course, which is to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in a said discipline of study.
2. **Professional Elective:** Elective relevant to chosen specialization/ branch
3. **Internship / Professional Practice:** To be carried out between 6th& 7th semester vacation or 7th& 8th semester vacation.

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Mijar, MOODBIDRI - 574 225

ENERGY ENGINEERING

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Energy Engineering	15ME71	04	3-2-0	80	20	3Hrs

Courselearning objectives is to

- Understand energy scenario,energy sources and their utilization
- Learn about energy conversion methods and their analysis
- Study the principles of renewable energy conversion systems
- Understand the concept of green energy and zero energy.

Module – I

Thermal Energy conversion system: Review of energy scenario in India,General Philosophy and need of Energy ,Different Types of Fuels used for steam generation,Equipment for burning coal in lump form, strokers, different types, Oilburners, Advantages and Disadvantages of using pulverized fuel, Equipmentfor preparation and burning of pulverized coal, unit system and bin system.Pulverized fuel furnaces, cyclone furnace, Coal and ash handling, Generationof steam using forced circulation, high and supercritical pressures.Chimneys: Natural, forced, induced and balanced draft, Calculations andnumerical involving height of chimney to produce a given draft. Coolingtowers and Ponds. Accessories for the Steam generators such asSuperheaters, De-superheater, control of superheaters, Economizers, Air preheatersand re-heaters.

9 Hours

Module – II

Diesel Engine Power System: Applications of Diesel Engines in Power field.Method of starting Diesel engines. Auxiliaries like cooling and lubricationsystem, filters, centrifuges, Oil heaters, intake and exhaust system, Layout ofdiesel power plant.

Hydro-Electric Energy: Hydrographs, flow duration and mass curves, unithydrograph and numerical. Storage and pondage, pumped storage plants, low, medium and high head plants, Penstock, water hammer, surge tanks,gates and valves. General layout of hydel power plants.

7 Hours

Module – III

Solar Energy: Fundamentals; Solar Radiation; Estimation of solar radiation on horizontal and inclined surfaces; Measurement of solar radiation data, Solar Thermal systems: Introduction; Basics of thermodynamics and heat transfer; Flat plate collector; Evacuated Tubular Collector; Solar air collector; Solar concentrator; Solar distillation; Solar cooker; Solar refrigeration and air conditioning; Thermal energy storage systems, Solar Photovoltaic systems: Introduction; Solar cell Fundamentals; Characteristics and classification; Solar cell: Module, panel and Array construction; Photovoltaic thermal systems

8 Hours

Module – IV

Wind Energy: Properties of wind, availability of wind energy in India, windvelocity and power from wind; major problems associated with wind power,wind machines; Types of wind machines and their characteristics, horizontaland vertical axis wind mills, coefficient of performance of a wind mill roton(Numerical Examples).

Tidal Power: Tides and waves as energy suppliers and their mechanics;fundamental characteristics of tidal power, harnessing tidal energy,limitations.

8 Hours

Module – V

Biomass Energy: Introduction; Photosynthesis Process; Biofuels; Biomass Resources; Biomass conversion technologies; Urban waste to energy conversion; Biomass gasification.

Green Energy: Introduction: Fuel cells: Overview; Classification of fuel cells; Operating principles; Fuel cell thermodynamics Nuclear, ocean, MHD, thermoelectric and geothermal energy applications; Origin and their types; Working principles, Zero energy Concepts

8 Hours

Course Outcomes

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

- Summarize the basic concepts of thermal energy systems,
- Identify renewable energy sources and their utilization.
- Understand the basic concepts of solar radiation and analyze the working of solar PV and thermal systems.
- Understand principles of energy conversion from alternate sources including wind, geothermal, ocean, biomass, biogas.
- Understand the concepts and applications of fuel cells, thermoelectric convertor and MHD generator.
- Identify methods of energy storage for specific applications

TEXT BOOKS:

1. B H Khan, Non conventional energy resources, 3rd Edition, McGraw Hill Education
2. Principles of Energy conversion, A. W. Culp Jr., McGraw Hill. 1996

REFERENCE BOOKS:

1. S.P. Sukhatme, Solar Energy: principles of Thermal Collection and Storage, Tata McGraw-Hill (1984).
2. C. S. Solanki, "Solar Photovoltaic's: Fundamental A pplications and Technologies, Prentice Hall of India, 2009.
3. L.L. Freris, Wind Energy Conversion Systems, Prentice Hall, 1990.

Scheme of Examination: Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

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Mijar, MOODBIDRI - 574 225

FLUID POWER SYSTEMS

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Fluid Power Systems	15ME72	04	3-2-0	80	20	3Hrs

Course objectives:

CLO1	To provide an insight into the capabilities of hydraulic and pneumatic fluid power.
CLO2	To understand concepts and relationships surrounding force, pressure, energy and power in fluid power systems.
CLO3	To examine concepts centering on sources of hydraulic power, rotary and linear actuators, distribution systems, hydraulic flow in pipes, and control components in fluid power systems.
CLO4	Exposure to build and interpret hydraulic and pneumatic circuits related to industrial applications.
CLO5	To familiarize with logic controls and trouble shooting

Module 1: Introduction to fluid power systems

Fluid power system: components, advantages and applications. Transmission of power at static and dynamic states. Pascal's law and its applications. Fluids for hydraulic system: types, properties, and selection. Additives, effect of temperature and pressure on hydraulic fluid. Seals, sealing materials, compatibility of seal with fluids. Types of pipes, hoses, and quick acting couplings. Pressure drop in hoses/pipes. Fluid conditioning through filters, strainers; sources of contamination and contamination control; heat exchangers.

10 hours

Module 2: Pumps and actuators

Pumps: Classification of pumps, Pumping theory of positive displacement pumps, construction and working of Gear pumps, Vane pumps, Piston pumps, fixed and variable displacement pumps, Pump performance characteristics, pump selection factors, problems on pumps.

Accumulators: Types, selection/ design procedure, applications of accumulators. Types of Intensifiers, Pressure switches /sensor, Temperature switches/sensor, Level sensor.

Actuators: Classification cylinder and hydraulic motors, Hydraulic cylinders, single and double acting cylinder, mounting arrangements, cushioning, special types of cylinders, problems on cylinders.

Construction and working of rotary actuators such as gear, vane, piston motors, and Hydraulic Motor. Theoretical torque, power,flowrate, and hydraulic motor performance; numerical problems. Symbolic representation of hydraulic actuators (cylinders and motors).

10 hours

Module3: Components and hydraulic circuit design

Components: Classification of control valves, Directional Control Valves-symbolic representation, constructional features of poppet, sliding spool, rotary type valves solenoid and pilot operated DCV, shuttle valve, and check valves.
Pressure control valves - types, direct operated types and pilot operated types.

Flow Control Valves -compensated and non-compensated FCV, needle valve, temperature compensated, pressure compensated, pressure and temperature compensated FCV, symbolic representation.

Hydraulic Circuit Design: Control of single and Double -acting hydraulic cylinder, regenerative circuit, pump unloading circuit, double pump hydraulic system, counter balance valve application,hydrauliccylinder sequencing circuits, cylinder synchronizing circuit using different methods, hydraulic circuit for force multiplication;speedcontrol of hydraulic cylinder- metering in, metering out and bleed off circuits.Pilot pressure operated circuits.Hydraulic circuit examples withaccumulator.

10 hours

Module4: Pneumatic power systems

Introduction to Pneumatic systems:Pneumatic power system, advantages, limitations, applications, Choice of working medium. Characteristics of compressed air and air compressors. Structure of pneumatic control System, fluid conditioners-dryers and FRL unit.

Pneumatic Actuators: Linear cylinder –types of cylinders, working, end position cushioning, seals, mounting arrangements, and applications. Rotary cylinders- types, construction and application, symbols.

Pneumatic Control Valves: DCV such as poppet, spool, suspended seat type slide valve, pressure control valves, flow control valves, types and construction, use of memory valve, Quick exhaust valve, time delay valve, shuttle valve, twin pressure valve, symbols.

10 hours

Module5: Pneumatic control circuits

Simple Pneumatic Control: Direct and indirect actuation pneumatic cylinders, speed control of cylinders - supply air throttling and exhaust air throttling.
Signal Processing Elements: Use of Logic gates - OR and AND gates in pneumatic applications.
Practical examples involving the use of logic gates.
Multi- Cylinder Application: Coordinated and sequential motion control, motion and control diagrams. Signal elimination methods, Cascading method-principle, Practical application examples (up to two cylinders) using cascading method (using reversing valves).
Electro- Pneumatic Control: Principles - signal input and output, pilot assisted solenoid control of directional control valves, use of relay and contactors. Control circuitry for simple signal cylinder application.

10 hours

COURSE OUTCOMES:
After studying this course, students will be able to:

CO1	Identify and analyse the functional requirements of a fluid power transmission system for a

	given application.
CO2	Visualize how a hydraulic/pneumatic circuit will work to accomplish the function.
CO3	Design an appropriate hydraulic or pneumatic circuit or combination circuit like electro-hydraulics, electro-pneumatics for a given application.
CO4	Select and size the different components of the circuit.
CO5	Develop a comprehensive circuit diagramby integrating the components selected for the given application.

TEXT BOOKS:

1. Anthony Esposito, "Fluid Power with applications", Pearson edition,2000 .
2. Majumdar S.R., "Oil Hydraulics",TalaMcGRawHIlL, 2002 .
3. Majumdar S.R., "Pneumatic systems - Principles and Maintenance",Tata McGraw-Hill, New Delhi, 2005

REFERENCE BOOKS:

1. John Pippenger, Tyler Hicks, "Industrial Hydraulics", McGraw Hill International Edition, 1980.
2. Andrew Par, Hydraulics and pneumatics, Jaico Publishing House, 2005.
3. FESTO, Fundamentals of Pneumatics, Vol I,IIandIII.
4. Herbert E. Merritt, "Hydraulic Control Systems", John Wiley and Sons, Inc.
5. Thomson, Introduction to Fluid power, PrentcieHall, 2004
6. John Watton, "Fundamentals of fluid power control", Cambridge University press, 2012.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Learning Assignment:

The faculty will allocate one or more of the following experiments from group A and B to group of students(containing not more than fourstudents in a group):

Group A: Experiments on hydraulic trainer:

a. Speed control circuit using metering in and metering out technique

b. Regenerative and sequencing circuits.

c. Extend-Retract and Stop system of a linear actuator

d.Rapid Traverse and Feed circuit.

Group B: Experimentson pneumatic trainer:

a. Automatic reciprocating circuit b. Speed control circuit

c. Pneumatic circuit involving shuttle valve/ quick exhaust valve

d. Electro pneumatic valves and circuit

H.O.D.
Dept. Of Mechanical Engineering
Alva's Institute of Engg. & Technology
Mijar, MOODBIDRI - 574 225

Students should build up the above circuits on computer using software and simulate the flow of fluid during the operation. Afterwards, they themselves can physically connect the circuit on the hydraulic/pneumatic trainer and run the circuit. Record of experiments shall be submitted in the form of journal. Due credit must be given for this assignment (5 Marks).

List of Open Source Software/learning website:

1. Simulink
2. SimHydraulics

CONTROL ENGINEERING

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Control Engineering	15ME73	04	3-2-0	80	20	3Hrs

Course Objectives	1. Modeling of mechanical, hydraulic, pneumatic and electrical systems. 2. Representation of system elements by blocks and its reduction 3. Transient and steady state response analysis of a system. 4. Frequency response analysis using polar plot. 5. Frequency response analysis using bode plot. 6. Analysis of system using root locus plots. 7. Different system compensators and variable characteristics of linear systems.

MODULE I

Introduction: Concept of automatic controls, Open loop and closed loop systems, Concepts of feedback, requirements of an ideal control system, Types of controllers-Proportional, Integral, Differential, Proportional & Integral, Proportional Differential and Proportional Integral Differential controllers.

(7 Hours)

MODULE 2

Modeling of Physical Systems : Mathematical Models of Mechanical, Electrical, Thermal, Hydraulic and Pneumatic Systems.
(3 hours)

Analogous Systems: Direct and inverse analogs for mechanical, thermal and fluid systems.

(4 hours)

Block diagram Algebra: General representation of a feedback control system, transfer functions, rules of block diagram algebra, reduction of block dia. to obtain closed loop transfer function.

Signal flow graphs : Mason's gain formula

(6 Hours)

MODULE 3

Steady state operation: Steady state analysis for general block dia. for a control system, steady state characteristics, equilibrium in a system. **(3 hours)**

Transient Response: Transient response and steady state analysis of unit, step input, general operational representation for a differential equation of control system, distinct, repeated and complex conjugate zeros, general form of transient response, Routh's stability criterion for a control system. **(4 hours)**

Root Locus Plots : Root locus method: Significance of Root locus, angle and magnitude conditions, breakaway points, angles of departure and arrival, construction of Root locus using general rules and steps, Lead and Lag compensation

(6 Hours)

MODULE 4

Frequency Domain Analysis: Relationship between time and frequency response, Polar plot, Bode's Plot, Nyquist plot and Nyquist stability criterion, Relative Stability, Phase and Gain Margins **(14 Hours)**

MODULE 5

System Compensation and State Variable Characteristics of Linear Systems : Series and feedback compensation, Introduction to state concepts, state equation of linear continuous data system. Matrix representation of state equations, controllability and observability, Kalmanand Gilberts test .

(7 Hours)

Course Outcomes
CO1: Recognize control system and its types , control actions
CO2: Determine the system governing equations for physical models(Electrical, Thermal, Mechanical, Electro Mechanical)
CO3: Calculate the gain of the system using block diagram and signal flow graph
CO4: Illustrate the response of 1st and 2nd order systems
CO5: Determine the stability of transfer functions in complex domain and frequency domain
CO6: Employ state equations to study the controllability and observability

H. O. D.
Dept. Of Mechanical Engineering
Alva's Institute of Engg. & Technology
Mijar, MOODBIDRI - 574 225

DESIGN OF THERMAL EQUIPMENTS

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Design of thermal Equipments	15ME741	03	3-0-0	80	20	3Hrs

Course objectives :

1. To understand types of heat exchanger
2. To study the design shell and tube heat exchanger
3. To study types and design of steam heat condenser and compact heat exchanger
4. To comprehend and design air cooled heat exchanger
5. To understand and to design air cooled heat exchanger, furnaces

Module I

Introduction To Heat Exchanger Design: Types of heat exchangers and their applications. Flow arrangements and temperature distributions in transfer type of heat exchangers. Overall heat transfer coefficient;- Clean overall heat transfer coefficient, dirt factor dirt overall heat transfer coefficient, dirt factors for various process services.

Double Pipe Heat Exchangers: Film coefficients for tubes and annuli, equivalent diameter of annuli, fouling factors, caloric or average fluid temperature, true temperature difference; Design calculation of double pipe heat exchanger, double pipe exchangers in series-parallel arrangements.**08 Hrs**

Module II

Shell and tube heat exchangers - tube layouts, baffle spacing, classification of shell and tube exchangers, Design calculation of shell and tube heat exchangers, flow assignments: tube side flow area calculations; viscosity correction factor, shell side equivalent diameter, calculation of shell side heat transfer coefficient, evaluation for wall temperature, evaluation of overall heat transfer coefficient, Calculation of surface area. Calculations of tube side and shell side pressure drops.

Module III **08 Hrs**

Steam Condensers: Specifications of other details as per TEMA standards. Flow arrangement for increased heat recovery: - lack of heat recovery in 1-2 exchangers true temperature difference in a 2-4 exchanger. Calculationprocedure for steam condensers.

Compact Heat Exchangers: Introduction; definition of Geometric Terms: plate fin surface geometries and surface performance data; correlation of heat transfer and friction data; Goodness factor comparisons; specification ofrating and sizing problems; calculation procedure for a rating problem.**08 Hrs**

Module IV

Air-Cooled Heat Exchangers: Air as coolant for industrial processes; custom-built units; fin-tube systems for air coolers; fin-tube bundles; thermal rating; tube side flow arrangements; cooling air supply by fans; cooling airsupply in natural draft towers.

Furnaces And Combustion Chambers: Introduction; process heaters and boiler; heat transfer in furnaces: - Heat source; Heat sink; refractory surfaces; heat transfer to the sink; Design methods: - Method of Lobo and Evans:Method of Wilson, Lobo and Hottel; The Orrok-Hudson equation;Wallenberg simplified method. **08 Hrs**

Module V

Heat pipes - types and applications, operating principles, working fluids, wick structures, control techniques, pressure balance, maximum capillary pressure, liquid and vapor pressure drops, effective thermal conductivity of wick structures, capillary limitation on heat transport capability, sonic, entrainment, and boiling limitations, determination of operating conditions; Heat pipe design – fluid selection, wick selection, material selection, preliminary design considerations, heat pipe design procedure, determination of heat pipe diameter, design of heat pipe containers, wick design, entertainment and boiling limitations, design problems **08 Hrs**

Course outcomes:

1. To have complete knowledge of heat exchanger and its applications
2. To be able to design shell and tube heat exchanger
3. To be able to select and design of steam heat condenser and compact heat exchanger condenser and heat pipes for various application

TEXT BOOKS:

1. **Process Heat Transfer**: Donald Q. Kern, Tata McGraw –Hill Edition (1997)
2. **Compact Heat Exchangers:** W. M. Kays & A. L. London, McGraw –Hill co. (1997)
3. **Heat Pipe Theory and Practice** Chi, S. W., - A Source Book, McGraw-Hill, 1976

REFERENCE BOOKS:

1. **Heat Transfer – A Basic Approach:** NecatiOzsisik, McGraw – Hill International edition (1985).
2. **Heat Exchanger Design Hand Book:** Volumes 2 and 3, edited by Ernst U schlunder. et. al Hemisphere Publishing Co. (1983)
3. **Heat exchanger-** Kokac Thermal- hydraulic and design analysis.
4. **Heat Pipes** Dunn, P. D. and Reay, D. A., , Fourth Edition, Pergamon Press, 1994

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Dept. Of Mechanical Engineering
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TRIBOLOGY

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Tribology	15ME742	03	3-0-0	80	20	3Hrs

Course objectives:

CLO1	To educate the students on theimportance of friction, the related theories/laws of sliding and rolling friction and the effect of viscosity of lubricants.
CLO2	To expose the students to the consequences of wear, wear mechanisms, wear theories and analysis of wear problems.
CLO3	Tomake the students understand the principles of lubrication, lubrication regimes, theories of hydrodynamic and the advanced lubrication techniques.
CLO4	To expose the students to the factors influencing the selection of bearing materials fordifferent sliding applications.
CLO5	To introduce the concepts of surface engineering and its importance in tribology.

Module 1

Introduction to tribology: Historical background, practical importance, and subsequent use in the field.

Lubricants: Types and specific field of applications. Properties of lubricants,viscosity, its measurement, effect of temperature and pressure on viscosity, lubrication types, standard grades of lubricants, and selection of lubricants.

8 hours

Module 2

Friction: Origin, friction theories, measurement methods, friction of metals and non-metals.

Wear: Classification and mechanisms of wear, delamination theory, debris analysis, testing methods and standards. Related case studies.

8 hours

Module3

Hydrodynamic journal bearings: Friction forces and power loss in a lightly loaded journal bearing, Petroff's equation, mechanism of pressure development in an oil film, and Reynold's equation in 2D.

Introduction to idealized journal bearing, load carrying capacity, condition for equilibrium, Sommerfeld's number and it ssignificance,partial bearings, and leakages in journal bearing, numerical examples on full journal bearings only.

10 hours

Module4

Plane slider bearings with fixed/pivoted shoe: Pressure distribution, Load carrying capacity, coefficient of friction, frictional resistance in a fixed/pivoted shoe bearing,center of pressure, numerical examples.

Hydrostatic Lubrication: Introduction to hydrostatic lubrication, hydrostatic step bearings, load carrying capacity and oil flow through the hydrostatic step bearing, numerical examples.

8 hours

Module5

Bearing Materials: Commonly used bearings materials, and properties of typical bearing materials. Advantages and disadvantages of bearing materials.

Introduction to Surface engineering: Concept and scope of surface engineering.

Surface modification – transformation hardening, surface melting, thermo chemical processes.

Surface Coating – plating,fusionprocesses, vapor phase processes.

Selection of coating for wear and corrosion resistance.

8 hours

COURSE OUTCOMES:

After studying this course, students will be able to:

CO1	Understand the fundamentals of tribology and associated parameters.
CO2	Apply concepts of tribology for the performance analysis and design of components experiencing relative motion.
CO3	Analyse the requirements and design hydrodynamic journal and plane slider bearings for a given application.
CO4	Select proper bearing materials and lubricants for a given tribological application.
CO5	Apply the principles of surface engineering for different applications of tribology.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Use of approved Design Data Handbook/charts can be permitted during the examination.

TEXTBOOKS:

1."Introduction to Tribology", B. Bhushan, John Wiley & Sons, Inc., New York, 2002

2. "Engineering Tribology", Prasanta Sahoo, PHI Learning Private Ltd, New Delhi, 2011. 3."Engineering Tribology", J. A. Williams, Oxford Univ. Press, 2005.

REFERENCES:

1. "Introduction to Tribology in bearings", B. C. Majumdar, Wheeler Publishing.
2. "Tribology, Friction and Wear of Engineering Material", I. M.Hutchings, Edward Arnold, London,1992.
3. "Engineering Tribology", G. W. Stachowiak and A. W. Batchelor, Butterworth-Heinemann,1992.
4. "Friction and Wear of Materials", Ernest Rabinowicz, John Wiley & sons,1995.
5. "Basic Lubrication Theory", A. Cameron, Ellis Hardwoods Ltd., UK.
6. "Handbook of tribology: materials, coatings and surface treatments", B.Bhushan, B.K. Gupta, McGraw-Hill,1997.

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Dept. Of Mechanical Engineering
Alva's Institute of Engg. & Technology
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MECHATRONICS

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Mechatronics	15ME753	03	3-0-0	80	20	3 Hrs

Course objectives:

1. Understand the evolution and development of Mechatronics as a discipline.
2. Substantiate the need for interdisciplinary study in technology education.
3. Understand the applications of microprocessors in various systems and to know the functions of each element
4. Demonstrate the integration philosophy in view of Mechatronics technology

MODULE -1

Introduction: Definition, Multidisciplinary Scenario, Evolution of Mechatronics,Design of Mechatronics system, Objectives, advantages and disadvantages ofMechatronics.

Transducers and sensors: Definition and classification of transducers, Differencebetween transducer and sensor, Definition and classification of sensors, Principleof working and applications of light sensors, proximity switches and Hall Effectsensors. 10 Hours

MODULE -2

Microprocessor &Microcontrollers: Introduction, Microprocessor systems,Basic elements of control systems, Microcontrollers, Difference betweenMicroprocessor and Microcontrollers.

Microprocessor Architecture: Microprocessor architecture and terminology-CPU,memory and address, I/O and Peripheral devices, ALU, Instruction andProgram, Assembler, Data, Registers, Program Counter, Flags, Fetch cycle, writecycle, state, bus interrupts. Intel's 8085A Microprocessor. 10 Hours

MODULE -3

Programmable logic controller: Introduction to PLC's, basic structure, Principleof operation, Programming and concept of ladder diagram, concept of latching &selection of a PLC.

Integration: Introduction & background, Advanced actuators, Pneumaticactuators, Industrial Robot, different parts of a Robot-Controller, Drive, Arm, EndEffectors, Sensor & Functional requirements of robot. 10 Hours

MODULE -4

Mechanical actuation systems: Mechanical systems, types of motion, Cams, Gear trains, Ratchet & Pawl, belt and chain drives, mechanical aspects of motorselection.

Electrical actuation systems: Electrical systems, Mechanical switches, Solenoids,Relays, DC/AC Motors, Principle of Stepper Motors & servomotors. 10 Hours

MODULE -5

Pneumatic and hydraulic actuation systems: Actuating systems, Pneumatic andhydraulic systems, Classifications of Valves, Pressure relief valves, Pressureregulating/reducing valves, Cylinders and rotary actuators.

DCV & FCV: Principle & construction details, types of sliding spool valve,

solenoid operated, Symbols of hydraulic elements, components of hydraulicsystem, functions of various units of hydraulic system. Design of simple hydraulicircuits for various applications. 10 Hours

Course outcomes:

On completion of this subject, students will be able to:

1. Illustrate various components of Mechatronics systems.
2. Assess various control systems used in automation.
3. Develop mechanical, hydraulic, pneumatic and electrical control systems.

TEXT BOOKS:

1. NitaigourPremchandMahalik , Mechatronics-Principles, Concepts and Applications, Tata McGraw Hill, 1st Edition, 2003 ISBN.No. 0071239243, 9780071239240.
2. W.Bolton-Pearson Education, Mechatronics – Elect ronic Control Systems in Mechanicaland Electrical Engineering, 1st Edition, 2005 ISBN No. 81-7758-284-4.

REFERENCE BOOKS:

1. Mechatronics by HMT Ltd. – Tata McGrawHill, 1 st Edition, 2000. ISBN:9780074636435.
2. Anthony Esposito, Fluid Power , Pearson Education, 6th Edition, 2011, ISBN No.9789332518544.

E- Learning

- VTU, E- learning

Scheme of Examination:

Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

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Mijar, MOODBIDRI

DESIGN LABORATORY

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Design Laboratory	15MEL76	02	1-0-2	80	20	3Hrs

Prerequisites: Knowledge of Dynamics and Machines and Design of Machine Elements

COURSE OBJECTIVES:

Students are expected-

1. To understand the natural frequency, logarithmic decrement, damping ratio and damping.
2. To understand the balancing of rotating masses.
3. To understand the concept of the critical speed of a rotating shaft.
4. To understand the concept of stress concentration using Photo elasticity.
5. To understand the equilibrium speed, sensitiveness, power and effort of Governor.

PART –A

1. Determination of natural frequency, logarithmic decrement, damping ratio and damping Co-efficient in a single degree of freedom vibrating systems (longitudinal and torsional)
2. Determination of critical speed of rotating shaft.
3. Balancing of rotating masses.
4. Determination of fringe constant of Photo-elastic material using Circular disk subjected diametric compression, Pure bending specimen (four point bending)
5. Determination of stress concentration using Photo elasticity for simple components like Plate with hole under tension or bending, circular disk with circular hole under compression, 2-d crane hook.

PART –B

1. Determination of equilibrium speed, sensitiveness, power and effort ofPorter/ Proel / Hartnell Governor. (at least one)
2. Determination of pressure distribution in Journal bearing
3. Determination of principle stresses and strain in a member subjected to combined loading using strain rosettes.
4. Determination of stresses in curved beam using strain gauge.
5. Experiments on Gyroscope (Demonstration only)

COURSE OUTCOMES

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

1. To understand the working principles of machine elements such as Governors, Gyroscopes etc.,
2. To identify forces and couples in rotating mechanical system components.
3. To identify vibrations in machine elements and design appropriate damping methods and to determine the critical speed of a rotating shaft.
4. To measure strain in various machine elements using strain gauges.
5. To determine the minimum film thickness, load carrying capacity, frictional torque and pressure distribution of journal bearing.
6. To determine strain induced in a structural member using the principle of photo-elasticity.

Scheme of Examination:

One question from Part A:	**32 Marks**
One question from part B:	**32 Marks**
Viva- Voce:	**16 Marks**
Total:	**80 Marks**

Reference Books:

[1] "Shigley's Mechanical Engineering Design", Rich ards G. Budynas and J. Keith Nisbett, McGraw-Hill Education, 10th Edition, 2015.

[2] "Design of Machine Elements", V.B. Bhandari, TM H publishing company Ltd. New Delhi, 2nd Edition 2007.

[3] "Theory of Machines", Sadhu Singh, Pearson Educ ation, 2nd Edition, 2007.

[4] "Mechanical Vibrations", G.K. Grover, Nem Chand and Bros, 6th Edition, 1996.

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COMPTER INTEGRATED MANUFACTURING LAB

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Computer Integrated Manufacturing LAB	15MEL77	02	1-0-2	80	20	3Hrs

Course Objectives:

CLO1	To expose the students to the techniques of CNC programming and cutting tool path generation through CNC simulation software by using G-Codes and M-codes.
CLO2	To educate the students on the usage of CAM packages.
CLO3	To make the students understand the importance of automation in industries through exposure to FMS, Robotics, and Hydraulics and Pneumatics.

Part-A

Manual CNC part programming for 2 turning and 2 milling parts.Selection and assignment of tools, correction of syntax and logical errors, and verification of tool path.

CNC part programming using CAM packages. Simulation of Turning, Drilling, Milling operations.

3 typical simulations to be carried out using simulation packages like:**CademCAMLab-Pro, Master- CAM.**

Program generation using software. Optimize spindle power, torque utilization, and cycle time. Generation and printing of shop documents like process and cycle time sheets, tool list, and tool layouts.Cut the part in single block and auto mode and measure the virtual part on screen. Post processing of CNC programs for standard CNC control systems like FANUC, SINUMERIC and MISTUBISHI.

Part B

(Only for Demo/Viva voce)

FMS (Flexible Manufacturing System): Programming of Automatic storage and Retrieval system (ASRS) and linear shuttle conveyor Interfacing CNC lathe, milling with loading unloading arm and ASRS to be carried out on simple components.

(Only for Demo/Viva voce)

Robot programming: Using Teach Pendent & Offline programming to perform pick and place, stacking of objects (2 programs).

Pneumatics and Hydraulics, Electro-Pneumatics: 3 typical experiments on Basics of these topics to be conducted.

Course Outcomes:

After studying this course, students will be able to:

CLO1	Generate CNC Lathe part program for Turning, Facing, Chamfering, Grooving, Step turning, Taper turning, Circular interpolation etc.
CLO2	Generate CNC Mill Part programming for Point to point motions, Line motions, Circular interpolation, Contour motion, Pocket milling- circular, rectangular, Mirror commands etc.
CLO3	Use Canned Cycles for Drilling, Peck drilling, Boring, Tapping, Turning, Facing, Taper turning Thread cutting etc.
CLO4	Simulate Tool Path for different Machining operations of small components using CNC Lathe & CNC Milling Machine.
CLO5	Use high end CAM packages for machining complex parts; use state of art cutting tools and related cutting parameters; optimize cycle time.
CLO6	Understand & write programs for Robotcontrol;understand the operating principles of hydraulics, pneumatics and electropneumatic systems. Apply this knowledge to automate & improve efficiency of manufacturing.

Scheme for Examination:
Two Questions from Part A - 60 Marks (30 +30)
Viva-Voce - 20 Marks
Total: 80 Marks

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Mijar, MOODBIDRI - 574 225.

OPERATIONS RESEARCH

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Operations Research	15ME81	4	3-2-0	80	20	3 Hrs

Course objectives:

1. To enable the students to understand the scientific methods of providing various departments of an organization with a quantitative basis of decision making.
2. To enable the studentsto understand the importance of various tools and techniques in finding optimal solutions to problems involving limited resources in the form of Men, Materials and machinery.

MODULE -1

Introduction: Evolution of OR, Definitions of OR, Scope of OR, Applications of OR, Phases in OR study. Characteristics and limitations of OR, models used in OR,

Linear Programming Problem (LPP), Generalized LPP- Formulation of problems as L.P.P. SolutionstoLPP by graphical method(Two Variables).

08 Hours

MODULE -2

LPP: Simplex method, Canonical and Standard form of LP problem, slack, surplus and artificial variables, Solutions to LPP by Simplex method, Big-M Method and Two Phase Simplex Method, Degeneracy in LPP. Concept of Duality, writing Dual of given LPP. Solutions to L.P.P by Dual Simplex Method.

12 Hours

MODULE -3

Transportation Problem: Formulation of transportation problem, types, initial basic feasible solution using North-West Corner rule, Vogel's Approximation method. Optimality in Transportation problem by Modified Distribution(MODI) method. Unbalanced T.P. Maximization T.P. Degeneracy in transportation problems, application of transportation problem.

Assignment Problem-Formulation, Solutions to assignment problems by Hungarian method, Special cases in assignment problems, unbalanced, Maximization assignment problems.

Travelling Salesman Problem (TSP). Difference between assignment and T.S.P, Finding best route by Little's method. Numerical Problems.

12 Hours

Network analysis: Introduction, Construction of networks, Fulkerson's rule for numbering the nodes, AON and AOA diagrams; Critical path method to find the expected completion time of a project, determination of floats in networks, PERT networks, determining the probability of completing a project, predicting the completion time of project; Cost analysis in networks. Crashingofnetworks- Problems.

Queuing Theory: Queuing systems and their characteristics, Pure-birth and Pure-death models (only equations), Kendall & Lee's notation of Queuing, empirical queuing models – Numerical on M/M/1 and M/M/C Queuing models. 10 Hours

MODULE -5

Game Theory: Definition, Pure Strategy problems, Saddle point, Max-Min and Min-Max criteria, Principle of Dominance, Solution of games with Saddle point. Mixed Strategy problems. Solution of 2X2 games by Arithmetic method, Solution of 2Xn m and mX2 games by graphical method. Formulationof games.

Sequencing: Basic assumptions, Johnson's algorithm, sequencing 'n' jobs on single machine using priority rules, sequencing using Johnson's rule-'n' jobs on 2 machines, 'n' jobs on 3 machines, 'n' jobs on 'm' machines. Sequencing of2 jobs on 'm' machines using graphical method. 08 Hours

Course outcomes:

On completion of this subject, students will be able to:

1. Understand the meaning, definitions, scope, need, phases and techniques of operations research.
2. Formulate as L.P.P and derive optimal solutions to linear programming problems by graphical method, Simplex method, Big-M method and Dual Simplex method.
3. Formulate as Transportation and Assignment problems and derive optimum solutions for transportation, Assignment and travelling salesman problems.
4. Solve problems on game theory for pure and mixed strategy under competitive environment.
5. Solve waiting line problems for M/M/1 and M/M/K queuing models.
6. Construct networkdiagrams and determine critical path, floats for deterministic and PERT networks including crashing of Networks.
7. Determine minimum processing times for sequencing of n jobs-2 machines, n jobs-3machines,n jobs-m machinesand 2 jobs-n machines using Johnson's algorithm.

TEXT BOOKS:

1. Operations Research, P K Gupta and D S Hira,S. Chand and Company LTD.

Publications, New Delhi – 2007

2. Operations Research, An Introduction, Seventh Edition, Hamdy A. Taha, PHI Private Limited, 2006.

REFERENCE BOOKS:

1. Operations Research, Theory and Applications, Sixth Edition, J K Sharma, Trinity Press, Laxmi Publications Pvt.Ltd. 2016.

2. Operations Research, Paneerselvan, PHI

3. Operations Research, A M Natarajan, P Balasubramani, PearsonEducation, 2005

4. Introduction to Operations Research, Hillier and Lieberman,8th Ed., McGraw Hill

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

H. O. D.
Dept. Of Mechanical Engineering
Alva's Institute of Engg. & Technology
Mijar, MOODBIDRI - 574 225

ADDITIVE MANUFACTURING

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Additive Manufacturing	15ME82	4	4-0-0	80	20	3 Hrs

Course Objectives:

Students will be able to

1. Understand the additive manufacturing process, polymerization and powder metallurgy process
2. Understand characterisation techniques in additive manufacturing.
3. Acquire knowledge on CNC and Automation.

	Module 1	
	Introduction to Additive Manufacturing: Introduction to AM, AM evolution, Distinction between AM & CNC machining, Advantages of AM, **AM process chain:** Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation, Machine setup, build , removal and clean up, post processing. **Classification of AM processes:** Liquid polymer system, Discrete particle system, Molten material systems and Solid sheet system. **Post processing of AM parts:** Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques. **Guidelines for process selection**: Introduction, selection methods for a part, challenges of selection **AM Applications:** Functional models, Pattern for investment and vacuum casting, Medical models, art models, Engineering analysis models, Rapid tooling, new materials development, Bi-metallic parts, Re-manufacturing. Application examples for Aerospace, defence, automobile, Bio-medical and general engineering industries	**10 Hours**
	Module 2	
	System Drives and devices: Hydraulic and pneumatic motors and their features, Electrical motors AC/DC and their features **Actuators:** Electrical Actuators; Solenoids, Relays, Diodes, Thyristors, Triacs, Hydraulic and Pneumatic actuators, Design of Hydraulic and Pneumatic circuits, Piezoelectric actuators, Shape memory alloys.	**8 Hours**
	Module 3	
	POLYMERS & POWDER METALLURGY **Basic Concepts:** Introduction to Polymers used for additive manufacturing: polyamide,	**12 Hours**

	Polydispersity and Molecular weight [MW], Molecular Weight Distribution [MWD] **Polymer Processing:** Methods of spinning for additive manufacturing: Wet spinning, Dry spinning, Biopolymers, Compatibility issues with polymers, Moulding and casting of polymers, Polymer processing techniques General Concepts: Introduction and History of Powder Metallurgy (PM), Present and Future Trends of PM **Powder Production Techniques:** Different Mechanical and Chemical methods, Atomisation of Powder, other emerging processes.**Characterization Techniques**: Particle Size & Shape Distribution, Electron Microscopy of Powder, Interparticle Friction, Compression ability, Powder Structure, Chemical Characterization **Microstructure Control in Powder:** Importance of Microstructure Study, Microstructures of Powder by Different techniques **Powder Shaping:** Particle Packing Modifications, Lubricants & Binders, Powder Compaction & Process Variables, Pressure & Density Distribution during Compaction, Isotactic Pressing, Injection Moulding, Powder Extrusion, Slip Casting, Tape Casting. **Sintering:** Theory of Sintering, Sintering of Single & Mixed Phase Powder, Liquid Phase Sintering Modern Sintering Techniques, Physical & Mechanical Properties Evaluation, Structure-Property Correlation Study, Modern Sintering techniques, Defects Analysis of Sintered Components **Application of Powder Metallurgy:** Filters, Tungsten Filaments, Self-Lubricating Bearings, Porous Materials, Biomaterials etc.	
	Module 4	
	NANO MATERIALS & CHARACTERIZATION TECHNIQUES: **Introduction:** Importance of Nano-technology, Emergence of Nanotechnology, Bottom-up and Top-down approaches, challenges in Nanotechnology **Nano-materials Synthesis and Processing:** Methods for creating Nanostructures; Processes for producing ultrafine powders- Mechanical grinding; Wet Chemical Synthesis of Nano-materials- sol-gel process; Gas Phase synthesis of Nano-materials- Furnace, Flame assisted ultrasonic spray pyrolysis; Gas Condensation Processing (GPC), Chemical Vapour Condensation(CVC). **Optical Microscopy** - principles, Imaging Modes, Applications, Limitations. **Scanning Electron Microscopy (SEM)** - principles, Imaging Modes, Applications, Limitations. **Transmission Electron Microscopy (TEM)** - principles, Imaging Modes, Applications, Limitations.**X- Ray Diffraction (XRD)** - principles, Imaging Modes, Applications, Limitations.**Scanning Probe Microscopy (SPM)** - principles, Imaging Modes, Applications, Limitations.**Atomic Force Microscopy (AFM)** - basic principles, instrumentation, operational modes, Applications, Limitations. **Electron Probe Micro Analyzer (EPMA)** - Introduction, Sample preparation, Working procedure, Applications, Limitations.	**10 Hours**
	Module 5	
	MANUFACTURING CONTROL AND AUTOMATION **CNC technology - An overview:** Introduction to NC/CNC/DNC machine tools.	**10 Hours**

	Classification of NC /CNC machine tools, Advantage, disadvantages of NC /CNC machine tools, Application of NC/CNC **Part programming:** CNC programming and introduction, Manual part programming: Basic (Drilling, milling, turning etc.), Special part programming, Advanced part programming, Computer aided part programming (APT) **Introduction:** Automation in production system principles and strategies of automation, basic Elements of an automated system. Advanced Automation functions. Levels of Automations, introduction to automation productivity **Control Technologies in Automation:** Industrial control system. Process industry vs discrete manufacturing industries. Continuous vs discrete control. Continuous process and its forms. Other control system components.	

Course Outcomes

1. Understand the different process of Additive Manufacturing. using Polymer, Powder and Nano materials manufacturing.
2. Analyse the different characterization techniques.
3. Describe the various NC, CNC machine programing and Automation techniques.

TEXT BOOKS:

1. Chua Chee Kai, Leong Kah Fai, "Rapid Prototyping: Principles & Applications", World Scientific, 2003.
2. G Odian Principles of Polymerization, Wiley Inerscience John Wiley and Sons, 4th edition, 2005
3. Mark James Jackson, Microfabrication and Nanomanufacturing, CRC Press, 2005.
4. Powder Metallurgy Technology, Cambridge International Science Publishing, 2002.
5. P. C. Angelo and R. Subramanian: Powder Metallurgy- Science, Technology and Applications, PHI, New Delhi, 2008.
6. Mikell P Groover, Automation, Production Systems and Computer Integrated Manufacturing, 3rd Edition, Prentice Hall Inc., New Delhi, 2007.

REFERENCE BOOKS:

1. Wohler's Report 2000 - Terry Wohlers - Wohler's Association -2000
2. Computer Aided Manufacturing - P.N. Rao, N.K. Tewari and T.K. Kundra Tata McGraw Hill 1999
3. Ray F. Egerton , Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM , Springer, 2005.
4. P. C. Angelo and R. Subramanian: Powder Metallurgy- Science, Technology and Applications, PHI, New Delhi, 2008.

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Dept. Of Mechanical Engineering
Alva's Institute of Engg. & Technology
Mijar, MOODBIDRI - 574 225

4. Design the rules and processes to meet the market need and the green manufacturing requirements by selecting and evaluating suitable technical, managerial / project management and supply chain management scheme.

PRODUCT LIFE CYCLE MANAGEMENT

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Product Life Cycle Management	15ME835	3	3-0-0	80	20	3 Hrs

Course objectives:

This course enables students to

1. Familiarize with various strategies of PLM
2. Understand the concept of product design and simulation.
3. Develop New product development ,product structure and supporting systems
4. Interpret the technology forecasting and product innovation and development in business processes.
5. Understand product building and Product Configuration.

MODULE 1:

INTRODUCTION TO PLM AND PDM

Introduction to PLM,Need for PLM,opportunities and benefits of PLM, different views of PLM, components of PLM, phases of PLM, PLM feasibility study. PLM Strategies, strategy elements, its identification, selection and implementation. Product Data Management, implementation of PDM systems.

8Hrs

MODULE 2:

PRODUCT DESIGN

Engineering design, organization and decomposition in product design, product design process, methodical evolution in product design, concurrent engineering, design for 'X' and design central development model. Strategies for recovery at end of life, recycling, human factors in product design. Modelling and simulation in product

8Hrs.

MODULE 3:

PRODUCT DEVELOPMENT

New Product Development, Structuring new product development, building decision support system, Estimating market opportunities for new product, new product financial control, implementing new product development, market entry decision, launching and tracking new product program. Concept of redesign of product.

8Hrs.

MODULE 4:

TECHNOLOGY FORECASTING

Technological change, methods of technology forecasting, relevance trees, morphological methods, flow diagram and combining forecast of technologies Integration of technological product innovation and product development in business processes within enterprises, methods and tools in the innovation process according to the situation, methods and tools in the innovation process according to the situation.

8Hrs.

MODULE 5:

PRODUCT BUILDING AND STRUCTURES

Virtual product development tools for components, machines, and manufacturing plants: 3D CAD systems, digital mock-up, model building, model analysis, production (process) planning, and product data technology, Product structures: Variant management, product configuration, material master data, product description data, Data models, Life cycles of individual items, status of items.

8Hrs

Scheme of Examination:
Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

Course Outcomes:
Student will be able to

1. Explain the various strategies of PLM and Product Data Management
2. Describe decomposition of product design and model simulation
3. Apply the concept of New Product Development and its structuring.
4. Analyze the technological forecasting and the tools in the innovation.
5. Apply the virtual product development and model analysis

Text Books:

1.Stark, John. *Product Lifecycle Management: Paradigm for 21st Century ProductRealisation*, Springer-Verlag, 2004. ISBN 1852338105

2.Fabio Giudice, Guido La Rosa, Product Design for the environment-A life cycle approach, Taylor & Francis 2006

Reference Books:

1.. Saaksvuori Antti / ImmonenAnselmic, product Life Cycle Management Springer,Dreamtech,3-540-25731-4

2. Product Lifecycle Management, Michael Grieves, Tata McGraw Hill

Internship/ Professional Practice

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Internship/ Professional Practice	15MES4	2	Industry Oriented	50	50	3 Hrs

Project Work, Phase II

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Project Work, Phase II	15MEP85	6	0-6-0	100	100	3 Hrs

Seminar

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Seminar	15MES86	1	0-4-0	100	-	-

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