NAVAL ARCHITECTURE

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]

SEMESTER – V

Subject Code	15 MR51	IA Marks	20
Number of Lecture Hrs / Week	03+02Tutorial	Exam Marks	80
Total Number of Lecture Hrs	50	Exam Hours	03
CREDITS – 04			

OBJECTIVES:

a) To impart Knowledge to students about Marine Vehicle Performance while sailing
b) Designing and manufacturing vehicles and structures that operate in the marine environment
c) Practicing professionally in the marine industries, enrolling in graduate study, and engaging in life Long learning.

COURSE OUTCOMES:

At the end of the course the students would have acquired the knowledge of:

a) an ability to apply knowledge of mathematics, science, and engineering within naval architecture and marine engineering;
b) Basic hydrostatics, Geometry of ship;
c) Calculations of ship forms and various co-efficients: Calculating the area of wetted surface, volume etc… .
d) an understanding of the various types of Propellers and Rudders;
e) an understanding of and experience in marine system conceptual and preliminary design using industrial capability.

MODULE 1

Geometry of Ship &**Hydrostatic Calculations :** Ships lines, Displacement Calculation, pressure exerted by a liquid, load on immersed plane ,centre of pressure, load diagram shearing force on bulkhead stiffener, Simpson's first rule, application to volumes, use of intermediate ordinates application to first and second moments of area. , Familiarisation with hydrostatic curves of ship, problems. **10hours**

MODULE 2

T.P.C, Co-efficient of forms: Concept of DWT, GT and NT, Tonnes per Cm. Immersion, Co-efficient of forms, wetted surface area, Similar figures, shearing force and bending moment

Centre of gravity: effect of addition and removal of masses, Effect of movement of mass, Effect of suspended mass calculations. **10 Hours**

MODULE 3

Stability of ships: Statical stability at small angles of heel. Calculation on BM, metacentric diagram inclining experiment, free surface effect, stability at large angle of heel, stability of wall sided vessel. Problems.

Resistance: Frictional, residuary and total resistance, Admiralty co-efficient fuel co-efficient and consumption, problems. **10 Hours**

MODULE 4

TRIM: Change in draughts due to added masses, change in mean draught and end draught due to density change in mean draught and end draught due to bilging MCTI, change of L.C.B. with change of trim, Change of trim due to adding or deducting weights, change in draft & trim because Of' filling/flooding several tanks with different densities, Change in draft due to change in density. Problems.

10 Hours

Module-5

PROPELLER AND RUDDER THEORY: Geometry of screw propeller, types of propeller, Blade element theory Apparent and real slip, wake, thrust, relation between powers, built and solid propellers, measurement of pitch, cavitation.

Force on rudder, types of rudders, model experiments and turning trails, torque on stock, angle of heel due to force on rudder, angle of heel when turning, problems. **10hours**

Text Books:

1.Ship and Naval Architecture, R. Munro-Smith

2. Naval Architecture for Engineers, Reeds' Vol — 6

Reference Books:

1. K.J.Rawson and E.C.Tupper, basic ship theory (vol II), 5THedition,butterheinmann London 2001
2. EAStokoe "Naval Architecture for Marine Engineers" vol 4, reeds publications, 2000
3. G.N.Hatdh, "creative naval architecture" 1st Edition, Thomas reed publications, London 1971

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.

MARINE INTERNAL COMBUSTION ENGINES 1

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]

SEMESTER – V

Subject Code	15 MR52	IA Marks	20
Number of Lecture Hrs / Week	04	Exam Marks	80
Total Number of Lecture Hrs	50	Exam Hours	03
CREDITS – 04			

COURSE OBJECTIVES:
The students should be able to have:

- A theoretical Knowledge of the marine diesel engines.
- A knowledge of the structural elements of a marine diesel engines
- A knowledge of the scavenging systems.
- Analyze of fuel and lubricating systems.

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

- Have an understanding of various types of Marine Diesel Engines.
- Have knowledge of various systems used in Marine Diesel Engine plants.
- Have knowledge of the theoretical aspect of Scavenging and super charging system.

Module 1:

PERFORMANCE CHARACTERISTICS OF I.C. ENGINE

4-Stroke and 2-Stroke cycles; Deviation from ideal condition in actual engines; Limitation in parameters, Timing Diagrams of 2-Stroke and 4-Stroke engines. Comparative study of slow speed, medium speed and high-speed diesel engines – suitability and requirements for various purposes. Mean Piston speed, M.C.R. & C.S.R. ratings. Practical heat balance diagrams and thermal efficiency.

10 hours

Module 2:

GENERAL DESCRIPTION OF MARINE DIESEL ENGINE:

Constructional Details of I.C. engines and marine diesel engines: components: jackets and liners, cylinder heads and fittings, pistons, cross heads, connecting rods, crank shaft, bearings, bed plates, Aframes, welded construction for bedplates & frames and tie rods etc.

COOLING OF I.C. ENGINES: Various cooling media, their merits and demerits, cooling of pistons, cylinder jackets & cylinder heads, bore cooling, coolant conveying mechanism and systems, maintenance of coolant and cooling system, cooling water: testing and treatment.

10 Hours

Module 3:

SCAVENGING SYSTEM:

Scavenging arrangements in 2-stroke engines; air charging and exhausting in 4-stroke engines; various types of scavenging in 2-stroke engines; uniflow, loop and cross flow scavenging, their merits and demerits, scavenge pumps for normally aspirated engines, under piston scavenging, scavenge manifolds.

TURBOCHARGING ARRANGEMENTS:

Pulse and constant pressure type; merits and demerits in highly rated marine propulsion engines. air movements inside the cylinders. Turbo charger and its details. **10 Hours**

Module 4:

ENGINE SAFETY AND FUEL:

Causes and prevention of crank-caseexplosions, and Scavenger fires. Detection of same and safety fittings provided to prevent damage,Uptake fire, Starting air line explosion, shore side and shipboard sampling and testing. treatment of fuel for contaminants including microbiological infection. combustion of fuel-air for combustion – combustion of hydro carbons(theoretical treatment). compression pressure ratio and its effect on engines. reasons for variation in compression pressure and peak pressure. .

10 Hours

Module 5:

MARINE LUBRICATING OIL:

Lubrication principles: introduction – friction – functions of lubricants – basic requirements – machine components – surface finish – types of lubricants – hydrodynamic or full fluid film lubrication – lubrication of slider bearings – hydrostatic lubrication – boundary lubrication – hydrodynamic lubrication,

SELECTION OF LUBRICANTS: Introduction – field of application – cylinder lubrication for large two stroke engines – crank case oil for large two stroke engines – lubricants for medium speed trunk piston engines medium / high and high – speed engines, Lubricating systems for various engines – monitoring engines through lubricating oil analysis reports**.** Treatment of Lube oil for contaminants including microbiological infection.

10 Hours

TEXT BOOKS:

1.D.A. Taylor, "Introduction to Marine Engineering", 2nd Edition, Butter worth – Heinemann, London, 1999

2. Wood yard, Doug, "Pounder‟s Marine Diesel Engines", 7th Edition, Butter Worth Heinemann Publishing, London, 2001.

3. Leslie Jackson, Thomos D Morton, Paul A Russell, "Motor Engineering Knowledge For Marine Engineers", 3rd Ed. Reeds Vol 12, Adlard Coles Nautical, London

REFERENCE:

1. M.E.P., "Low Speed Diesel Engines New", Marine Engineering Practice, Vol-2 Part-17,,IMarEST, London

2. S. H. Henshall, "Medium and High Speed Diesel Engines for Marine Use", 1st Edition, Institute of Marine Engineers, Mumbai, 1996.

3. D.K. Sanyal, "Principle & Practice of Marine Diesel Engines", 2nd Edition, Bhandarkar Publication, Mumbai, 1998.

4. Mathur, M.L., Sharma, R.P., " Internal Combustion Engines", 7th Ed. Dhanpat rai Publications, REPRINT 2002

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.

MARINE AUXILLARY MACHINERY-1

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]

SEMESTER – V

Subject Code	15 MR53	IA Marks	20
Number of Lecture Hrs / Week	04	Exam Marks	80
Total Number of Lecture Hrs	50	Exam Hours	03
CREDITS – 04			

COURSE OBJECTIVES:

The students should be able to have:

- A theoretical Knowledge of the auxiliary equipments on ships.
- A knowledge of engine room pipeline systems.
- A knowledge of the heat exchanger systems.
- Understanding of steering systems

COURSE OUTCOMES:

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

1	Have an understanding of the engine room layout and systems
2	Have a knowledge of the heat exchangers and distillation systems
3	Have a understanding of the steering systems.

Module 1:

Engine Room Layout , Piping Systems And Fittings :

Layout of main and auxiliary machinery in Engine Rooms in different ships. Steam and condensate system, water hammering in pipes, Expansion joints in pipelines, Bilge – ballast, fuel oil bunkering and transfer system, bunkering procedure, precautions taken, fuel oil service system to main and auxiliary engines, lubricating oil and Engine cooling system to main and auxiliary engines, central cooling and central priming systems, control and service air system, domestic fresh water and sea water (Hydrophore) service system, drinking water system, fire main system.

10 Hours

Module 2:

Valves, Cocks , Packing, Joints, Filters And Stainers :

Straight way cocks, right angled cock,T‟ cock, spherical cock, Boiler gauge glass cock (cylindrical cock). Globe valves, SDNR valve, swing check valve (storm valve), gate valves, butterfly valves, relief valves, quick closing valves, pressure reducing valves, control valves, change over valve chests, fuel oil transfer chest, valve actuators, steam traps. Packings, Insulation of materials, Types,- Various applications. Seals – purpose of bearing seal, description and application of non rubbing seals and rubbing seals, simple felt seal, seals suitable for various peripheral speeds, V-ring seals, Lip seals. Filtration, filter elements basket strainers, duplex strainers, edge type strainers, auto-kleen strainers, back flushing strainers, magnetic filter, rotary filters, fine filters.

10 Hours

Module 3:

Pumps :

Types of pumps for various requirements – their characteristics, performance and application in ships – centrifugal pumps – gear pumps – screw pumps and reciprocating pumps – care and maintenance of pumps,operation of all pumping systems on board such as bilge, ballast and cargo pumping operations.

10 Hours

Module 4:

HEAT EXCHANGERS, EVAPORATORS AND DISTILLERS

Principle of surface heat transfer – description, contact heat transfer, construction of shell and tube type – flat plate type, single and double pass – lubricating oil coolers, fuel oil heaters, fresh water coolers, compressed air coolers, Main Engine charge air cooler, Fresh water heaters, steam condensers, evaporators and condensers in refrigeration system – materials used in all the above heat exchangers, expansion allowance – temperature controls effect of air in the system – maintenance. Distillation of water, distilling equipment, problem of scale formation and method of controlling, methods of distillation, single effect and double effect shell type evaporator, low pressure vacuum type evaporator, flash evaporators, multiple effect evaporators-construction and operation salt water leaks and detection, reverse osmosis desalination plant, membranes, drinking water and treatment.

10 Hours

Module 5:

STEERING SYSTEM

Hydraulic Telemotor system (Transmitter and receiver), Bypass valve – charging system, – hydraulic power unit – hunting gear heleshaw pump principle, construction and operation – pawl and ratchet mechanism, 2-ram and 4-ram steering gear – All electric steering gear, principle and operation – Hunting gear and emergency steering gear. Electro-hydraulic steering gear, Raphson and slide Actuators, Rotary vane steering gear – principle – construction – operation – safety features, relief, isolating and bypass valves, steering system regulations and testing – trouble shooting – rectification maintenance. **10 Hours**

TEXT BOOKS:

1. D.W. Smith, “Marine Auxillary Machinery”, 6th Edition, Butter worths, London, 1987.
2. H.D. McGeorge, “Marine Auxillary Machinery”, 7th Edition, Butter worth, London,2001.

REFERENCE:

1. H.D. McGeorge, “General Engineering Knowledge”, 3rd edition, Butter worth – Heineman, London, 1991.

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.

TURBOMACHINES

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]

SEMESTER – V

Subject Code	15 MR54	IA Marks	20
Number of Lecture Hrs / Week	03+02 Tutorial	Exam Marks	80
Total Number of Lecture Hrs	50	Exam Hours	03
CREDITS – 04			

COURSE OBJECTIVES:

1. To provide Students with a comprehensive classification of compressible fluid machines (positive displacement machines and turbo machines)
2. To enable students to design mechanical components of turbines (such as blades) and understand the velocity triangles for such type of turbo-machines.
3. To give an integrated view of various types of compressors (such as axial & centrifugal compressors) and explain the performance as well as the design considerations for these types of compressors.
4. To clearly understand water turbine characteristics, performance principles, design aspects and the performance analysis of multi-stage turbines.
5. To explain centrifugal pumps (performance, impeller design) and flow problems; particularly losses, cavitations

COURSE OUTCOMES:

The student shall be able to

1. Identify and differentiate positive displacement machine and turbo machines.
2. Explain the working principles of turbo machines and apply it to various types of machines.
3. Analyze energy transfer through graphical and analytical methods in turbo machines.
4. Determine the velocity triangles for different turbo machinery and able to Apply the affinity laws to pumps and turbines.
5. Design different kinds of turbo machines.

MODULE 1:

Introduction: Definition of turbomachine, parts of turbomachines, Comparison with positive displacement machines, Classification, Dimensionless parameters and their significance, Effect of Reynold's number, Unit and specific quantities, model studies. Application of first and second law's of thermodynamics to turbomachines, Efficiencies of turbomachines. Problems.

Thermodynamics of fluid flow: Static and Stagnation states- Incompressible fluids and perfect gases, overall isentropic efficiency, stage efficiency (their comparison) and polytropic efficiency for both compression and expansion processes. Reheat factor for expansion process problems.

10 Hours

MODULE 2:

Energy exchange in Turbomachines: Euler's turbine equation, Alternate form of Euler's turbine equation, Velocity triangles for different values of degree of reaction, Components of energy transfer, Degree of Reaction, utilization factor, Relation between degree of reaction and Utilization factor, Problems.

General Analysis of Turbomachines: Radial flow compressors and pumps – general analysis, Expression for degree of reaction, velocity triangles, Effect of blade discharge angle on energy transfer and degree of reaction, Effect of blade discharge angle on performance, Theoretical head – capacity relationship, General analysis of axial flow pumps and compressors, degree of reaction, velocity triangles, Problems. **10 Hours**

MODULE 3:

Steam Turbines: Classification, Single stage impulse turbine, condition for maximum blade efficiency, stage efficiency, Need and methods of compounding, Multi-stage impulse turbine, expression for maximum utilization factor, Reaction

turbine – Parsons's turbine, condition for maximum utilization factor, reaction staging. Problems (Graphical/Analytical)

10 Hours

MODULE 4:

Hydraulic Turbines: Classification, Different efficiencies, Pelton turbine – velocity triangles, design parameters, Maximum efficiency. Francis turbine - velocity triangles, design parameters, runner shapes for different blade speeds. Draft tubes- Types and functions. Kaplan and Propeller turbines - velocity triangles, design parameters.Problems.

10 Hours

MODULE 5:

Centrifugal Pumps: Classification and parts of centrifugal pump, different heads and efficiencies of centrifugal pump, Minimum speed for starting the flow, Maximum suction lift, Net positive suction head, Cavitation, Need for priming, Pumps in series and parallel. Problems.

Centrifugal Compressors: Stage velocity triangles, slip factor, power input factor, Stage work, Pressure developed, stageefficiency and surging and problems. Axial flow Compressors: Expression for pressure ratio developed in a stage, work done factor, efficiencies and stalling. Problems.

10 Hours

(Note: Since dimensional analysis is covered in Fluid Mechanics subject, questions on dimensional analysis may not be given. However, dimensional parameters and model studies may be given more weightage.)

TEXT BOOKS:

1. An Introduction to Energy Conversion, Volume III, Turbo machinery, V. Kadambi and Manohar Prasad, New Age International Publishers, reprint 2008.
2. Turbines, Compressors & Fans, S. M. Yahya, Tata McGraw Hill Co. Ltd., 2nd edition, 2002

REFERENCE BOOKS:

1. Principals of Turbomachines, D. G. Shepherd, The Macmillan Company (1964).
2. Fluid Mechanics & Thermodynamics of Turbomachines, S. L. Dixon, Elsevier (2005).
3. Text Book of Turbomachines, M. S. Govindgouda and A. M. Nagaraj, M. M. Publications, 4Th Ed, 2008.
4. Turbomachine, B.K.Venkanna PHI, New Delhi 2009.

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.

MARINE ENGINE LAB

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]

SEMESTER – V

Subject Code	15MRL57	IA Marks	20
Number of Lecture Hrs / Week	01	Exam Marks	80
No of Practical Hours / Week	02	Exam Hours	03
CREDITS – 02			

COURSE OBJECTIVES:

To impart skills to students to demonstrate the ability to carry out the different tests to understand the performance characteristics of Diesel engines

COURSE OUTCOMES

Students will be able to

1. To perform various tests on the heat engines
2. To analyse the results to understand the performance characteristics of engines
3. To choose the best fuels and lubricants based on the test results.

PART - A

1. Determination of Flash point and Fire point of lubricating oil using Abel Pensky and Marten's (closed) / Cleavland's (Open Cup) Apparatus.
2. Determination of Calorific value of solid, liquid and gaseous fuels.
3. Determination of Viscosity of lubricating oil using Redwoods, Saybolt and Torsion Viscometers.
4. Valve Timing/port opening diagram of an I.C. engine (4 stroke/2 stroke).
5. Use of planimeter

PART - B

1. Performance Tests on I.C. Engines, Calculations of IP, BP, Thermal efficiencies, Volumetric efficiency, Mechanical efficiency, SFC, FP, A:F Ratio heat balance sheet for
   (a) Four stroke Diesel Engine
   (b) Four stroke Petrol Engine
   (c) Multi Cylinder Diesel/Petrol Engine, (Morse test)
   (d) Two stroke Petrol Engine
   (e) Variable Compression Ratio I.C. Engine.

Scheme of Examination:

ONE question from part -A:	**25 Marks (10 write up+15)**
ONE question from part -B:	**40 Marks (10 write up+30)**
Viva -Voice:	**15 Marks**
Total :	**80 Marks**

FLUID MECHANICS LAB

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]

SEMESTER – V

Subject Code	**15MRL58**	IA Marks	20
Number of Lecture Hrs / Week	01	Exam Marks	80
No of Practical Hours / Week	02	Exam Hours	03
CREDITS – 02			

COURSE OBJECTIVES

Students are expected-

- To compare the results of analytical models introduced in lecture to the actual behavior of real fluid flows
- To discuss and practice standard measurement techniques of fluid mechanics and their applications
- To learn and practice writing technical reports
- To work on small design projects.

COURSE OUTCOMES

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

- Students can able to understand to analyze practical problems in all power plants and chemical industries
- Conduct experiments (in teams) in pipe flows and open-channel flows and interpreting data from model studies to prototype cases, as well as documenting them in engineering reports
- Analyze a variety of practical fluid-flow devices and utilize fluid mechanics principles in design
- Given the required flow rate and pressure rise, select the proper pump to optimize the pumping efficiency

PART – A

1. Determination of coefficient of friction of flow in a pipe.
2. Determination of minor losses in flow through pipes.
3. Determination of force developed by impact of jets on vanes.
4. Calibration of flow measuring devices
    a. Orifice Plate meter
    b. Nozzle
    c. Venturimeter
    d. V-notch

PART – B

1. Performance testing of Turbines
    a. Pelton wheel
    b. Francis Turbine
    c. Kaplan Turbines
2. Performance testing of Pumps
    a. Single stage / Multi stage centrifugal pumps
    b. Reciprocating pump
3. Performance test of a two stage Reciprocating Air Compressor
4. Performance test on an Air Blower

Scheme of Examination:

ONE question from part -A:	**25 Marks (10 write up+15)**
ONE question from part -B:	**40 Marks (10 write up+30)**
Viva -Voice:	**15 Marks**
Total :	**80 Marks**

Professional Elective-1

DESIGN OF MACHINE ELEMENTS

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]

SEMESTER – V

Subject Code	15MR551	IA Marks	20
Number of Lecture Hrs / Week	02+02 Tutorial	Exam Marks	80
Total Number of Lecture Hrs	42	Exam Hours	03
CREDITS – 03			

COURSE OBJECTIVES:

This course provides

- Be able to analyse the stress and strain on mechanical components; and understand, identify and quantify failure modes for mechanical parts.

COURSE OUTCOMES:

The student shall be able to

1. At the completion of the course the students are expected to have knowledge in,
2. Using Different types of Bearings.
3. Design of IC Engine parts and gears.
4. Design of Marine Machinery systems.

MODULE 1:

Introduction: Definitions: normal, shear, biaxial and tri axial stresses, Stress tensor, Principal Stresses. Engineering Materials and their mechanical properties, Stress-Strain diagrams, Design considerations: Codes and Standards

Design For Static & Impact Strength: Static Strength: Static loads and factor of safety, Theories of failure: Maximum normal stress theory, Maximum shear stress theory, Maximum strain theory, Strain energy theory, Distortion energy theory. Failure of brittle and ductile materials, Stress concentration, Determination of Stress concentration factor. Impact Strength: Introduction, Impact stresses due to axial, bending and torsional loads, effect of inertia.

9 hours

MODULE 2:

Design For Fatigue Strength: Introduction- S-N Diagram, Low cycle fatigue, High cycle fatigue, Endurance limit, Modifying factors: size effect, surface effect, Stress concentration effects, Fluctuating stresses, Goodman and Soderberg relationship, stresses due to combined loading, cumulative fatigue damage

8hours

MODULE 3:

Design Of Shafts: Torsion of shafts, design for strength and rigidity with steady loading, ASME codes for power transmission shafting, shafts under fluctuating loads and combined loads.

Cotter And Knuckle Joints: Design of Cotter and Knuckle joints.

8hours

MODULE 4:

IC Engine Parts and Bearings: Design of piston, Design of trunk pistons , buckling of connecting rod, forces in connecting rod, cross section for connecting rod, design procedure for connecting rod, design procedure for crank shaft.center crankshaft at top dead center position and at an angle of maximum torque, side or overhung crankshaft at top dead center position and at an angle of maximum torque

Bearings: bearing modulus co-effcient of friction minimum oil film thickness heat generated an heat dissipated and bearing materials .examples of journal bearing and thrust bearing.

9 hours

MODULE 5:

Spur & Helical Gears: Spur Gears: Definitions, stresses in gear tooth, Lewis equation and form factor, Design for strength, Dynamic load and wear load. Helical Gears: Definitions, formative number of teeth, Design based on strength, dynamic and wear loads.

8 hours

DESIGN DATA HANDBOOK:

1. **Design Data Hand Book** , K. Lingaiah, McGraw Hill, 2 Ed.
2. **Data Hand Book**, K. Mahadevan and Balaveera Reddy, CBS Publication
3. **Design Data Hand Book**, H.G. Patil, I. K. International Publisher, 2010

TEXT BOOKS:

1. Mechanical Engineering Design, Joseph E Shigley and Charles R. Mischke. McGraw Hill International edition, 6th Edition 2003.
2. Design of Machine Elements, V. B Bhandari, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition 2007

REFERNCE BOOKS:

1. Machine Design, Robert L. Norton, Pearson Education Asia, 2001
2. Design of Machine Elements, M. F. Spotts, T. E. Shoup, L. E. Hornberger, S. R. Jayram and C. V. Venkatesh, Pearson Education, 2006.
3. Machine Design, Hall, Holowenko, Laughlin (Schaum's Outlines series) Adapted by S.K. Somani, Tata McGraw Hill Publishing Company Ltd., New Delhi, Special Indian Edition, 2008

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.

ENERGY ENGINEERING

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]

SEMESTER – V

Subject Code	15 MR552	IA Marks	20
Number of Lecture Hrs / Week	02+02 Tutorial	Exam Marks	80
Total Number of Lecture Hrs	42	Exam Hours	03
CREDITS – 03			

COURSE OBJECTIVES:

This course provides

1. The foundation for understanding the steam power plant and boilers for marine engineering.
2. Topics are designed to explore the energy conversion techniques
3. Concepts of accessories and problem associated with energy conversion
4. Concepts of use of solar, wind, tidal energy applications are highlighted.

COURSE OUTCOMES:

The student shall be able to

1. Describe the steam power plant and boilers for the power generation application.
2. Understand the concept of steam generator
3. Explain the diesel engines used for power generation.
4. Understand the working of nuclear and hydro power plants.
5. Know about composite solar energy, wind energy , tidal energy and geothermal energy .

Module -1

Steam Power Plant: Different Types of Fuels used for steam generation, Equipment for burning coal in lump form, strokers, different types, Oil burners, Advantages and Disadvantages of using pulverized fuel, Equipment for preparation and burning of pulverized coal, unit system and bin system. Pulverized fuel furnaces, cyclone furnace, Coal and ash handling, Generation ofsteam using forced circulation, high and supercritical pressures. **09 hours**

Module -2

A Brief Account of Benson, Velox Schmidt Steam Generators.

Chimneys: Natural, forced, induced and balanced draft, Calculations and numerical involving height of chimney to produce a given draft. Cooling towers and Ponds. Accessories for the Steam generators such as super heaters, De super heater, control of super heaters, Economizers, Air pre heaters and re-heaters.**Diesel Engine Power Plant:** Applications of Diesel Engines in Power field. Method of starting Diesel engines. Auxiliaries like cooling and lubrication system, filters, centrifuges, Oil heaters, intake and exhaust system, Layout of diesel power plant. **08 hours**

Module -3

Nuclear Power Plant: Principles of release of nuclear energy; Fusion and fission reactions. Nuclear fuels used in the reactors. Multiplication and thermal utilization factors.Elements of the nuclear reactor; moderator, control rod, fuel rods, coolants. Brief description of reactors of the following types-Pressurized water reactor, Boiling water reactor, Sodium graphite reactor,Fast Breeder reactor, Homogeneous graphite reactor and gas cooled reactor, Radiation hazards, Shielding, Radioactive waste disposal.

Hydro-Electric Plants: Hydrographs, flow duration and mass curves, unit hydrograph 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. **08 hours**

Module -4

Solar Energy: Solar Extra terrestrial radiation and radiation at the earth surface, radiation-measuring instruments, working principles of solar flat plate collectors, solar pond and photovoltaic conversion (Numerical Examples).

Wind Energy: Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, wind machines; Types of wind machines and their characteristics, horizontal and vertical axis wind mills, coefficient of performance of a wind mill rotor (Numerical Examples). **9 hours**

Module -5

Tidal Power: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, limitations. **Ocean Thermal Energy Conversion**: Principle of working, Rankine cycle, problems associated with OTEC.

Geothermal Energy Conversion: Principle of working, types of geothermal station with schematic diagram, problems associated with geothermal conversion, scope of geothermal energy. **Energy From Bio Mass**: Photosynthesis, photosynthetic oxygen production, energy plantation. **Bio Chemical Route:** Biogas production from organic wastes by anaerobic fermentation, classification of bio gas plants, factors affecting bio gas generation. **8 hours**

Text Books:

1. **Power Plant Engineering**, P. K. Nag Tata McGraw Hill 2nd edn 2001.
2. **Power Plant Engineering,** Domakundawar, Dhanpath Rai sons. 2003

Reference Books:

1. **Power Plant Engineering,** R. K. Rajput, Laxmi publication, New Delhi.
2. **Principles of Energy conversion**, A. W. Culp Jr., McGraw Hill. 1996
3. **Non conventional Energy sources**, G D Rai Khanna Publishers.
4. **Non conventional resources,** B H Khan TMH - 2007

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.

MARINE MANUFACTURING TECHNOLOGY

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]

SEMESTER – V

Subject Code	15 MR553	IA Marks	20
Number of Lecture Hrs / Week	02+02Tutorial	Exam Marks	80
Total Number of Lecture Hrs	42	Exam Hours	03
CREDITS – 03			

COURSE OBJECTIVES:

The students should be able to have:

- A theoretical Knowledge of students on the process of manufacture of Marine Components.

COURSE OUTCOMES:

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

1	Have an understanding of the metal joining process.
2	Have knowledge of the casting process.
3	Have knowledge of the metal forming, machining, finishing process.

Module 1:

Metal Joining Processes

Classification plastic welding, fusion welding, solid phase welding and sub classification. Study of power sources, electrodes, processes and applications: SMAW, SAWM, GTAW, GMAW, PAW, electro gas welding and Electro Slag, resistance welding. Gas welding, oxy acetylene cutting, brazing and soldering. Under water welding. Defects and Inspection of welded joints.

9 hours

Module 2:

Casting Processes

Sand casting, pattern and core making, moulding process - sand properties, melting furnaces – pit furnace and electric furnaces. Special casting processes – shell, investment, die casting – pressure and gravity types – squeeze casting - defects in casting - Plastic moulding – injection and blow moulding, and moulding – testing and inspection., Defects in shafting

9 hours

Module 3:

Finishing Processes

Surface finishing processes: grinding processes, various types of grinders, work holding devices, grinding wheels and specification, selection of grinding wheels for specific applications – selection of cutting speed and work speed. Fine Finishing Process: Lapping, honing, and super finishing process , ship hull finishing. **8 hours**

Module 4:

Metal Forming Processes

Hot and cold working processes – rolling, forging, drawing and extrusion processes, bending, hot spinning, shearing, tube and wire drawing, cold forming, shot peening. Sheet metal working – blanking, piercing, punching, trimming, Bending – types of dies – progressive, compound and combination dies. High-energy rate forming processes. **8 hours**

Module 5:

Machining Processes

Lathe: working principle, classification, specification accessories, lathe and tool holders, different operations on a lathe, methods of taper turning machining time and power required for cutting, Drilling and boring - classification, specification, cutters speed feed, machining time parts and description of parts parts-boring machines- jig borer –description, types and hole location procedures – milling - classification, principle, parts- specification milling cutters indexing, selection of milling m/c fundamentals of inches processes, milling processes and operations – CNC machines. **8 hours**

TEXT BOOKS:

1. Kemp & Young, " Ship construction : Sketches and Notes", 1st Ed. Standfor Maritime Limited, 1982
2. Jeffus, Welding and Metal fabrication",1st Ed. Cengage, Indian reprint 2012 (YesdeePublishings Pvt. Ltd.).
3. Rao.P.N., "Manufacturing Technology, Metal Cutting and Machine Tools", Tata McGraw-Hill, 2000.
4. Shan, H.S., " Manufacturing processes", Vol I, 1st Ed. Pearson, 2013

REFERENCES:

1. Jain K.C. Agarwal, L.N. "Metal Cutting Science and Production Technology",1st edition, Khanna Publishers, 1986.
2. Chapman W.A.J., "Workshop Technology", Vol. II, Arnold Publishers.
3. H.M.T., "Production Technology", Tata McGraw-Hill, New Delhi, 2000.
4. SeropeKalpakjian ,Steven,R. Schmid, "Manufacturing Engineering and Technology," 4th Ed. Pearson, 2011
5. Timings, " Fabrication and Welding Engineering", Elsevier, Indian Reprint 2011, YesdeePublishings Pvt. Ltd.

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.

STEAM ENGINEERING

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]

SEMESTER V

Subject code:	15MR554	IA marks	20
Number of Lecture Hrs / Week	02+02 Tutorial	Exam marks	80
Total Number of Lecture Hrs	42	Exam Hour	03
CREDITS – 03			

COURSE OBJECTIVES:

The students should be able to have:

- A theoretical Knowledge in Marine Steam Engines and Turbines and Applied Thermodynamics.

COURSE OUTCOMES:

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

1	Completed the detailed study of steam cycles, steam engines, steam nozzle and Turbines
2	Have a knowledge to calculate the efficiencies of Steam Turbine plant

Module 1:

Steam And Vapour Power Cycles : Carnot cycle for steam and ideal efficiency. Rankine cycle with dry, saturated and super heated steam.Modified Rankine, Reheat and Regenerative cycles.Binary vapour power cycles. Feed pump working. Isentropic efficiency, cycle efficiency, work ratio. Reheating and Regenerative feed heating and their effect on thermal efficiency.

9 hours

Module 2:

Marine steam engine : Modified rankine cycle for steam engines. Hypothetical indicator diagram. Mean effective pressure and work transfer – diagram factor. Indicated power – specific steam consumption – indicated thermal efficiency – efficiency ratio. Energy balance – compound steam engines.

8 hours

Module 3:

Steam Nozzles : General flow analysis. velocity at exit. critical pressure ratio and maximum mass flow. convergent and convergent-divergent nozzles – isentropic flow –effect of friction. nozzle area at the throat and exit. problems of steam flow through nozzles.

8 hours

Module 4:

Marine Stream Turbine Plants : General principle of Impulse and Reaction Turbines. Compounding of steam turbines - Pressure and Velocity compounding, stage efficiency overall efficiency and re-heat factor. Multi-Stage Turbine with regenerative and reheat cycles. Maximum work output condition. Typical steam plant with turbines, condensers and boilers.Thermal efficiency of steam turbine plant.

9 hours

Module 5:

Basic Principle Of Heat Transfer :

Conduction: Fourier law of Conduction. One dimensional Heat Diffusion equation. **Convection:** Forced and Free Convection. **Radiation:** Stefan-Boltzmann's equation. Law of Radiation – Problems.

8 hours

TEXT BOOKS:

1. Thomas, D. Morton, “Steam Engineering Knowledge For Marine Engineers”, 3rd Ed. Reeds Vol 09, Adlard Coles Nautical, London

2. Coats, “Marine Steam Turbines”, Marine Engineering Practice, Vol 1,Part 08, IMarEST, London
3. P.K. Nag, “Basic & Applied Thermodynamics”, 1st Edition, Tata McGraw–Hill Publishing Co., Ltd., New Delhi, 2002.
4. T.D. Eastop and McConkey, “Applied Thermodynamics for Engineering Technologist SI units”, 2nd Edition, ELBS with DP Publications, London, 1993.

REFERENCE:

1. Y.V.C. Rao, “Thermodynamics”, 2nd Edition, Wiley Eastern Ltd., New Delhi, 1993.
2. E. Ratha Krishnan, “Fundamentals of Engineering Thermodynamics”, 1st Edition, Prentice – Hall of India, New Delhi, 2000.
3. Gorden Rogers, Yon Mayhew, “ Engineering Thermodynamics Work and Heat Transfer”, 4th Ed. Pearson,2011
4. Marine Engineering Series, “Steam Turbines and Gearing”, 1st Ed. Stanford Maritime limited, London, 1982
5. Naterer, “Heat Transfer in Single and Multiphase Systems”, 1st Ed., Taylor & Francis, Indian reprint 2009,(YesdeePublishings Pvt. Ltd.)

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.

Open Elective-1

OPERATIONS RESEARCH

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]

SEMESTER – V

Subject Code	15 MR561	IA Marks	20
Number of Lecture Hrs / Week	02+02Tutorial	Exam Marks	80
Total Number of Lecture Hrs	42	Exam Hours	03
CREDITS – 03			

COURSE OBJECTIVES:

This course provides

1. To introduce the students to linear programming and to make them understand about the scope of OR
2. To make students learn about the simplex method.
3. To learn transportation problems and interpret solutions.
4. To make students learn about sequencing problems.
5. To learn about queuing theory and applications.
6. To learn about critical path and PERT analysis.
7. To learn about game theory and its applications.

COURSE OUTCOMES:

The student shall be able to

1. Students gained the knowledge of linear programming and scope of operations research.
2. Students learnt about the simplex method.
3. Students gained knowledge about transportation problems and interpretation of solutions.
4. Students learnt about sequencing.
5. Students learnt about waiting line models.
6. Students gained knowledge about PERT and CPM problems.
7. Students studied game theory and applications.

MODULE 1

Introduction: Evolution of OR, definition of OR, scope of OR, application areas of OR, steps (phases) in OR study, characteristics and limitations of OR, models used in OR, linear programming (LP) problem – formulation and solution by graphical method.

09Hours

MODULE 2

LPP: Simplex method-canonical and standard form of an LP problem, slack, surplus and artificial variables

Sequencing: Basic assumptions, 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 2 jobs on 'm' machines using graphical method.

09 Hours

MODULE 3

PERT-CPM: Introduction, network construction - rules, Fulkerson's rule for numbering the events, AON and AOA diagrams; Critical path method to find the expected completion time of a project, floats; PERT for finding expected duration of an activity and project, determining the probability of completing a project, predicting the completion time of project; crashing of simple projects.

08 Hours

MODULE 4

Queuing Theory: Queuing systems and their characteristics, Pure-birth and Pure-death models (only equations), empirical queuing models – M/M/1 and M/M/C models and their steady state performance analysis.

Game theory: Formulation of games, types, solution of games with saddle point, graphical method of solving mixed strategy games, dominance rule for solving mixed strategy games.

08 Hours

MODULE 5

Transportation Problem: Formulation of transportation problem, types, initial basic feasible solution using different methods, optimal solution by MODI method, unbalanced transportation problem, degeneracy in transportation problems, application of transportation problem, concept for maximization cases.

Assignment problem - formulation, types, application to maximization cases and travelling salesman problem.

08Hours

Text Book:

1. Operations Research, P K Gupta and D S Hira, Chand Publications, New Delhi - 2007
2. Operations Research, Taha H A, Pearson Education

Reference books:

1. Operations Research, A P Verma, S K Kataria&Sons, 2008
2. Operations Research, Paneerselvan, PHI
3. Operations Research, A M Natarajan, P Balasubramani, Pearson Education, 2005
4. Introduction to Operations Research, Hillier and Liberman,8th Ed., McGraw Hill
5. Operations Research S.D. Sharma, LedarnathRamanath& Co, 2002

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.

ENERGY AND ENVIRNOMENT

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]

SEMESTER – V

Subject Code	15 MR562	IA Marks	20
Number of Lecture Hrs / Week	02+02Tutorial	Exam Marks	80
Total Number of Lecture Hrs	42	Exam Hours	03
CREDITS – 03			

COURSE OBJECTIVES:

This course provides

- To impart knowledge about the importance of keeping the environment ,ecosystems without any kind of pollution and effective use of natural resources

COURSE OUTCOMES:

At the end of the course the students would have learnt about,

1. Environment and its eco systems
2. Types of pollution and the method of controlling the pollution
3. Planning and methods of preserving the natural resources
4. .Health and the effect of environment on the health of humans
5. Methods of disposal of different kind of wastes

MODULE 1

ENVIRONMENT, ECOSYSTEMS AND BIODIVERSITY Definition, scope and importance of Risk and hazards; Chemical hazards, Physical hazards, Biological hazards in the environment – concept of an ecosystem – structure and function of an ecosystem – producers, consumers and decomposers-Oxygen cycle and Nitrogen cycle – energy flow in the ecosystem – ecological succession processes – Introduction, types, characteristic features, structure and function of the (a) forest ecosystem (b) grassland ecosystem (c) desert ecosystem (d) aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries) – Introduction to biodiversity definition: genetic, species and ecosystem diversity – biogeographical classification of India – value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values – Biodiversity at global, national and local levels – India as a mega-diversity nation – hot-spots of biodiversity – threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts – endangered and endemic species of India – conservation of biodiversity: In-situ and ex-situ conservation of biodiversity.

09 Hours

MODULE 2

Definition – causes, effects and control measures of: (a) Air pollution (Atmospheric chemistry- Chemical composition of the atmosphere; Chemical and photochemical reactions in the atmosphere - formation of smog, PAN, acid rain, oxygen and ozone chemistry;- Mitigation procedures- Control of particulate and gaseous emission, Control of SO2, NOX, CO and HC) (b) Water pollution : Physical and chemical properties of terrestrial and marine water and their environmental significance; Water quality parameters – physical, chemical and biological; absorption of heavy metals - Water treatment processes. (c) Soil pollution - soil waste management: causes, effects and control measures of municipal solid wastes – (d) Marine pollution (e) Noise pollution (f) Thermal pollution (g) Nuclear hazards–role of an individual in prevention of pollution.

09 Hours

MODULE 3

NATURAL RESOURCES Forest resources: Use and over-exploitation, deforestation, case studies- timber extraction, mining, dams and their effects on forests and tribal people – Water resources: Use and overutilization of surface and ground water, dams-benefits and problems – Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies – Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies – Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Energy Conversion processes – Biogas – production and uses, anaerobic digestion; case studies – Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification – role of an individual in conservation of natural resources – Equitable use of resources for sustainable lifestyles. Introduction to Environmental Biochemistry: Proteins –Biochemical degradation of pollutants, Bioconversion of pollutants.

09 Hours

MODULE 4

SOCIAL ISSUES AND THE ENVIRONMENT

From unsustainable to sustainable development – urban problems related to energy – water conservation, rain water harvesting, watershed management – resettlement and rehabilitation of people; its problems and concerns, case studies – role of non-governmental organization- environmental ethics: Issues and possible solutions – 12 Principles of green chemistry- nuclear accidents and holocaust, case studies. – wasteland reclamation – consumerism and waste products – environment production act – Air act – Water act – Wildlife protection act – Forest conservation act –The Biomedical Waste (Management and Handling) Rules; 1998 and amendments- scheme of labelling of environmentally friendly products (Ecomark). enforcement machinery involved in 84 environmental legislation- central and state pollution control boards- disaster management: floods, earthquake, cyclone and landslides. Public awareness.

09 Hours

MODULE 5

HUMAN POPULATION AND THE ENVIRONMENT Population growth, variation among nations – population explosion – family welfare programme – environment and human health – human rights – value education – HIV / AIDS – women and child welfare –Environmental impact analysis (EIA)- -GIS-remote sensing-role of information technology in environment and human health – Case studies.

06Hours

Text Book:

1. Gilbert M.Masters, „Introduction to Environmental Engineering and Science", 2nd edition, Pearson Education (2004).
2. Benny Joseph, „Environmental Science and Engineering", Tata McGraw-Hill, New Delhi, 2006.

Reference books:

1. R.K. Trivedi, „Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards", Vol. I and II, Enviro Media.
2. Cunningham, W.P. Cooper, T.H. Gorhani, „Environmental Encyclopedia",Jaico Publ., House, Mumbai, 2001.
3. Dharmendra S. Sengar, „Environmental law", Prentice hall of India PVT LTD,New Delhi,2007.

4. Rajagopalan, R, „Environmental Studies-From Crisis to Cure", Oxford University Press, 2005.
5. Akola Debi, Environmental Science and Engineering, 2nd Ed. University press 2012.

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.

MANAGEMENT INFORMATION SYSTEM

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]

SEMESTER – V

Subject Code	15MR563	IA Marks	20
Number of Lecture Hrs / Week	02+02Tutorial	Exam Marks	80
Total Number of Lecture Hrs	42	Exam Hours	03
CREDITS – 03			

COURSE OBJECTIVES:

This course provides

1. To Identify the basic elements various aspects of MIS
2. To Construct MIS applied to engineering problems in a systematic manner
3. To recognize the Impart the knowledge of fundamentals of data base.
4. To design and evaluate the performance of different business applications

COURSE OUTCOMES:

The student shall be able to

1. To identify and enumerate basic elements various aspects of MIS
2. To Verify MIS applied to engineering problems in a systematic manner
3. To understand the purpose, impart the knowledge of fundamentals of data base.
4. To design and evaluate the performance of different business applications

MODULE 1

The Information Age: An Overview: The purpose, data, information, and information systems and their types, ethical and societal issues, information systems in business functions, web empowered enterprises.

Managing with Information and its Resources: Managing in 21st Century, Strategic planning and IS, Information needs for strategic planning, IS for decision support, Quality and privacy issues. Information resource management, strategic planning for IS function.

9Hours

MODULE 2

Information systems and Organizations: Relationship between organizations and information systems, feature of organizations, effect of organizations on information systems, effect of information systems on organizations.

Information Management and Decision-making: Role of managers, Decision-making, Individual models of decision-making, Organizational models of decision-making.

9 Hours

MODULE 3

Strategic Uses of Information Systems: Strategies and Strategic moves, Achieving a competitive advantage, creating and maintaining strategic information systems, Business Functions and Supply Chains – effectiveness and efficiency, accounting, finance, engineering, supply chain management, Human resource management, Enterprise resource planning.

8 Hours

MODULE 4

Information System Development: system development life cycle and methodologies, principles of system design. System analysis- Definition, Strategies and Phases. Object Oriented Technology: Object orientation,

object oriented analysis (OOA), system development through OOT, Object Oriented Languages. OOT and MIS.

8Hours

MODULE 5

Decision Support Systems: Decision support and expert systems – decision support and decision making process, structured and unstructured problems, decision support systems, expert systems, geographical systems, Business Intelligence .

Data Mining and online analysis, knowledge managements issues, Structure Constructions approaches, generators, tools, software and cost benefits and simple examples of applications.

8Hours

Text Books:

1. Management information systems organization and technology, 4 th edition - Kenneth C.Laudon and Jane P.Laudon, , Prentice Hall India/Pearson Education.
2. Systems analysis and design methods, 4 th edition - Jeffery L.Whitten and LonnieD.Bentley, Tata McGraw Hill.

Reference Books:

1. Management Information Systems-Conceptual foundations, Structure and development - Davis.G.B, McGraw Hill Intl.Book.Co.
2. Management Information Systems - Robert Schulties and Marry summer, TataMcGraw Hill Publishing Co., Ltd. New Delhi.
3. Management Information System- A Concise Study - S.A.Kelkar, PHI.
4. Management Information systems - W.S Jawadekar, TMH

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.

MICRO AND SMART TECHNOLOGY

[AS PER CHOICE BASED CREDIT SYSTEM (CBCS) SCHEME]

SEMESTER – V

Subject Code	15 MR564	IA Marks	20
Number of Lecture Hrs / Week	02+02Tutorial	Exam Marks	80
Total Number of Lecture Hrs	42	Exam Hours	03
CREDITS – 03			

COURSE OBJECTIVES:

This course provides

- Knowledge of Micro and Smart system Technology is essential for Mechatronic students and the course aims at training students in smart Mechatronic systems, sensors etc.

COURSE OUTCOMES:

The student shall be able to

- Students will be able to demonstrate their knowledge in Micro and Smart System Technology in Industrial applications.

MODULE 1

Introduction to Micro and Smart Systems:

a) What are smart-material systems? Evolution of smart materials, structures and systems.Components of a smart system. Application areas. Commercial products.

b) What are microsystems? Feynman's vision. Micro machined transducers. Evolution of micro-manufacturing. Multi-disciplinary aspects. Applications areas. Commercial products.

Micro And Smart Devices And Systems: Principles And Materials:

a) Definitions and salient features of sensors, actuators, and systems.

b) Sensors: silicon capacitive accelerometer, piezo-resistive pressure sensor, blood analyser, conduct metric gas sensor, fibber-optic gyroscope and surface-acoustic-wave based wireless strain sensor.

c) Actuators: silicon micro-mirror arrays, piezo-electric based inkjet print head, electrostatic comb-drive and micro motor, magnetic micro relay, shape memory-alloy based actuator, electro-thermal actuator

d) Systems: micro gas turbine, portable clinical analyser, active noise control in a helicopter cabin

09 Hours

MODULE 2

Micro-Manufacturing and Material Processing:

a) Silicon wafer processing, lithography, thin-film deposition, etching (wet and dry), wafer-bonding, and metallization.

b) Silicon micromachining: surface, bulk, moulding, bonding based process flows.

c) Thick-film processing:

d) Smart material processing:

e) Processing of other materials: ceramics, polymers and metals

f) Emerging trends

08 Hours

MODULE 3

Modelling:

a) Scaling issues.

b) Elastic deformation and stress analysis of beams and plates. Residual stresses and stress gradients. Thermal loading.Heat transfer issues.Basic fluids issues.

c) Electrostatics. Coupled electromechanics.Electromagnetic actuation.Capillary electro-phoresis. Piezo resistive modelling. Piezoelectric modelling.Magnetostrictive actuators.

08 Hours

MODULE 4

Integration and Packaging Of Microelectro Mechanical Systems:
Integration of microelectronics and micro devices at wafer and chip levels. Microelectronic packaging: wire and ball bonding, flip-chip. Lowtemperature-cofired-ceramic (LTCC) multi-chip-module technology. Microsystem packaging examples.

08 Hours

MODULE 5
Electronics, Circuits and Control:
Carrier concentrations, semiconductor diodes, transistors, MOSFET amplifiers, operational amplifiers.Basic Op-Amp circuits.Charge-measuring circuits.Examples from microsystems. Transfer function, state-space modelling, stability, PID controllers, and model order reduction. Examples from smart systems and micro machined accelerometer or a thermal cycler.

09 Hours

Text Book:
1. "Micro and Smart Systems" by Dr.A.K.Aatre, Prof.Ananth Suresh, Prof.K.J.Vinoy, Prof. S. Gopalakrishna,,Prof.K.N.Bhat.,John Wiley Publications
2. **MEMS & Microsystems: Design and Manufacture,** Tai-Ran Tsu, Tata Mc-Graw-Hill.

Reference books:
1. Animations of working principles, process flows and processing techniques, A CD-supplement with Matlab codes, photographs and movie clips of processing machinery and working devices.
2. **Laboratory hardware kits for** (i) BEL pressure sensor, (ii) thermal-cycler and (iii) active control of a cantilever beam.
3. **Microsystems Design,** S. D. Senturia, 2001, Kluwer Academic Publishers, Boston, USA. ISBN 0-7923-7246-8.
4. **Analysis and Design Principles of MEMS Devices,** MinhangBao, Elsevier, Amsterdam, The Netherlands, ISBN 0-444-51616-6.
5. **Design and Development Methodologies,** Smart Material Systems and MEMS: V. Varadan, K. J. Vinoy, S. Gopalakrishnan, Wiley.
6. MEMS- NitaigourPremchandMahalik, TMH 2007

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.