REVISED CURRICULUM
OF
Mechanical Engineering

Curriculum Development Project
Sponsored by
Ministry of Science & Technology
Islamabad

HIGHER EDUCATION COMMISSION
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CURRICULUM DIVISION, HEC

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PREFACE

Curriculum of a subject is said to be the throbbing pulse of a nation. By looking at the curriculum of a subject, one can judge the state of intellectual development and the state of progress of a nation. The world has turned into a global village, new ideas and information are pouring in a constant stream. It is, therefore, imperative to update our curricula by introducing the recent developments in the relevant fields of knowledge.

In exercise of the powers conferred by Sub-section (1) of section 3 of the Federal Supervision of Curricula Textbooks and Maintenance of Standards of Education Act 1976, the Federal Government vide Notification No.D773/76-JEA (Cur.), dated December 4, 1976, appointed Higher Education Commission as the Competent Authority to look after the Curriculum Revision Work beyond Class XII at Bachelor level and onwards to all Degrees, Certificates and Diplomas awarded by Degree Colleges, Universities and other Institutions of higher education.

In pursuance of the above decisions and directives, the Commission is continually performing curriculum revision in collaboration with the Universities. According to the decision of the special meeting of Vice-Chancellors' Committee, curriculum of a subject must be reviewed after every 3 years. For the purpose, various Committees are constituted at the national level comprising senior teachers nominated by the Universities. Teachers from local degree colleges and experts from user organizations, where required, are also included in these Committees.

The National Curriculum Revision Committee on **Mechanical Engineering** in its meeting held in July 2003 at the H.E.C. Regional Centre, Karachi finalized the draft curriculum after due consideration of the comments and suggestions received from the Universities and Colleges where the subject under consideration is taught.

The Final draft prepared by the Curriculum Revision Committee duly approved by competent authority is being circulated for implementation by the Universities.

(PROF. DR. ALTAF ALI G. SHAIKH)
D.G. (CURRICULUM)

August 2003

INTRODUCTION

The final meeting of National Curriculum Revision Committee in Mechanical Engineering was held from 19-21 August, 2003 at the Higher Education Commission, Regional Centre, Karachi to finalize the draft curriculum prepared in the preliminary meeting held on September 24-26, 2003. The following attended.

1.	Dr Ijaz Ahmad Malik Head, Department of Mechanical Engineering College of Electrical & Mechanical Engineering National University of Sciences & Technology Rawalpindi	Convener
2.	Prof. Dr. Riaz Mirza, Department of Mechanical Engineering, University of Engineering & Technology, Lahore	Member
3.	Engr. Bashir Ahmed Leghari Chairman, Department of Mechanical Engineering Balochistan University of Engineering & Technology. Khuzdar.	Member
4.	Dr. Khalil Ahmad Khan Professor and Chairman Department of Mechanical Engineering, NED University of Engineering & Technology, Karachi.	Member
5.	Dr. Abdul Sami Memon Associate Professor, Department of Mechanical Engineering, Quaid-e-Awam University of Engineering, Science and Technology, Nawabshah.	Member
6.	Engr. Ashfaque Ahmad Memon Associate Professor Department of Mechanical Engineering Mehran University of Engineering & Technology Jamshoro	Member
7.	Mr. Mohammad Aqil Manager (CNC) Pakistan Machine Tool Factory PMTF Road (Off National Highway) Karachi	Member

8. Mr. Abdul Aziz Khan — Member
Deputy Manager
Central Design Bureau
Pakistan Steel, Bin Qasim
Karachi

9. Prof. Dr. Irfan Ullah. — Member/Secretary
Department Of Mechanical Engineering,
NWFP University of Engineering & Technology,
Peshawar.

The meeting started with recitation from the Holy Quran.

Prof. Dr. Altaf Ali G. Shaikh, D. G. Curriculum HEC on the behalf of Chairmen HEC welcomed the participants. He explained the objectives and emphasized the importance of the meeting. Mr. Dholan Khiyani, Director, HEC, Regional Centre, Karachi assured the participants for providing all possible assistance and sectorial work/typing enabling them to finalize the draft curriculum. The committee, before taking up the regular agenda, elected Dr Ijaz Ahmad Malik as its Convener in place of Prof. Dr. Arshad Hussain Qureshi, who was unable to attend this meeting.

The committee discussed the feedback received from various universities and other institutions and accommodated the suggestions in the courses.

SCHEME OF STUDIES FOR B.E./B.Sc

CORE/COMPULSORY COURSES

Design Engineering

1.	Engineering Drawing & Graphics	(2,4)
2.	Engineering Statics	(2,2)
3.	Engineering Dynamics	(2,2)
4.	Mechanics of Materials-I	(2,2)
5.	Mechanics of Materials-II	(2,2)
6.	Mechanics of Machines-I	(2,2)
7.	Mechanics of Machines-II	(2,2)
8.	Machine Design-I	(2,0)
9.	Machine Design-II	(2,0)
10.	CAD/CAM Laboratory	(0,4)
11.	Measurement & Instrumentation	(2,2)
12.	Control Engineering	(2,2)

Manufacturing Engineering

13.	Engineering Materials	(2,2)
14.	Workshop Practice	(0,3)
15.	Manufacturing Processes-I	(2,2)
16.	Manufacturing Processes-II	(2,2)
17.	Industrial Management & Economics	(2,0)

Thermo-Fluids Engineering

18.	Thermodynamics-I	(2,2)
19.	Thermodynamics-II	(2,2)
20.	Fluid Mechanics-I	(2,2)
21.	Fluid Mechanics-II	(2,2)
22.	Heat & Mass Transfer	(2,2)
23.	I.C. Engines	(2,2)
24.	Power Plants	(2,2)

Supporting Courses

25.	Computer Systems and Programming	(1,3)
26.	Electrical Engineering	(2,2)
27.	Electronics	(2,2)
28.	Applied Mathematics-I	(2,0)
29.	Applied Mathematics-II	(2,0)
30.	Applied Mathematics-III	(2,2)
31.	Engineering Statistics	(2,0)
32.	Islamic and Pakistan Studies/Ethics	(2,0)
33.	English	(2,0)
34.	Technical Writing & Presentation Skills	(2,0)
35.	**Projects**	(0,6)

ELECTIVE COURSES

1.	Mechanical Vibrations	(2,2)
2.	Refrigeration & Air Conditioning	(2,2)
3.	Energy Resources & Utilization	(2,2)
4.	Gas Dynamics	(2,2)
5.	Aerodynamics	(2,2)
6.	Steam and Gas Turbines	(2,2)
7.	Manufacturing Automation	(2,2)
8.	Maintenance Engineering	(2,0)
9.	Quality Engineering	(2,0)
10.	Introduction to Mechatronics	(2,2)
11.	Robotics and Manufacturing Automation	(2,2)
12.	Operations Research	(2,2)
13.	Machine Dissection Practice	(0,2)
14.	Tribology	(2,0)
15.	Nuclear Engineering	(2,2)
16.	Environmental Engineering	(2,0)

DETAILOF COURSES FOR B.E./B.Sc

Compulsory Courses

1. Engineering Drawing & Graphics (Contact Hours/Week (2,4))

Part-I

Introduction. Types of lines, lettering, dimensioning, drawing instruments, planning of drawing sheet.

Projections. Types of projections, orthographic projections, plane of projections, four quadrants, projection of points, projection of straight lines, examples with different quadrants, traces of a line, true length of a line, inclination to both the planes, projection of oblique and auxiliary planes.

Loci of Points and Generated Curves. Loci of points and straight lines. Cycloid, epicycloid, involute, archemedian spiral.

Development of Solids. Types of solids, polyhedra, solids of revolution, prism, pyramid, cylinder, cone, sphere.

Intersection of Surfaces. Intersection of cylinder and cylinder, cone and cylinder, cone and cone, cone and prism.

Axonometric Projections. Types, Isometric projections of solids, planes, typical examples.

Projection in Auxiliary Planes. Auxiliary planes and views, projection of points, line, plane.

Projection of Solids. Projection of various solids in simple position and inclined positions.

Section of Solids. True shape of section on auxiliary plane of various solids.

Part-II

Isometric and pictorial projections of solids/machine parts, making of freehand sketches from solid objects and from orthographic projections. Sections of joints, screw thread systems, nuts and bolts, keys and cotter, coupling and simple bearings, pipe connections and engine details, preparation of assembly drawings.

Recommended Books

1. Engineering Drawing and Graphics by T. E. French, C. J. Vierck, R.J. Foster
2. Practical Geometry & Engineering Graphics by Abbot.
3. Engineering Graphics by Craft, Meyers & Boyer

2. Engineering Statics (Contact Hours/Week (2,2))

Force System. Force, rectangular components, moment, resultant couple (two and three dimensional systems).

Equilibrium. Mechanical systems, isolation and equilibrium conditions for two and three dimensional systems.

Structures. Plane trusses, method of joints, method of sections, frames.

Friction. Types of friction, dry friction, application of friction.

Recommended Books

1. Engineering Mechanics (Vol. 1) by R.C. Hibbler
2. Engineering Mechanics (Vol. 1) by J.L. Meriam & L.G. Kraige
3. Engineering Mechanics (Vol. 1) by F.P. Beer & E.R. Johnston
4. Engineering Mechanics (Vol. 1) by I. H. Shames

3. Engineering Dynamics (Contact Hours/Week (2,2))

Kinematics of Particles. Rectilinear motion, plane curvilinear motion, rectangular coordinates, normal and tangential coordinates, polar coordinates.

Kinetics of Particles. Force, mass, and acceleration, Newton's second law of motion, equations of motion, rectilinear motion, curvilinear motion. Work and energy, potential energy. Impulse and momentum, conservation of momentum.

Plane Kinematics of Rigid Bodies. Angular motion relations, absolute motion, relative velocity, instantaneous centre of zero velocity, relative acceleration.

Plane Kinetics of Rigid Bodies: Force, mass, and acceleration, general equation of motion, translation, fixed axis rotation, work and energy relationship, impulse and momentum equation.

Recommended Books

1. Engineering Mechanics (Vol. 2) by R.C. Hibbler
2. Engineering Mechanics (Vol. 2) by J.L. Meriam & L.G. Kraige
3. Engineering Mechanics (Vol. 2) by F.P. Beer & E.R. Johnston
4. Engineering Mechanics (Vol. 2) by I. H. Shames

4. Mechanics of Materials-I (Contact Hours/Week (2,2))

Mechanical properties of materials, elastic constants and their relationships, tensile, compressive and shear stress and strain, compound bars, thermal stresses. Moments of inertia, shearing force and bending moment, pure bending of beams, shear stresses in beams, deflection of beams. Torsion of circular bars, hollow and compound shafts. Strain energy, theory of columns.

Recommended Books

1. Mechanics of Materials by F. P. Beer & E.R. Johnston
2. Mechanics of Engineering Materials by P.P. Benham & R.J. Crawford
3. Mechanics of Solids & Strength of Materials by F.V. Warnock
4. Strength of Materials by F.L. Singer

5. Mechanics of Materials-II (Contact Hours/Week (2,2))

Plane stress and strain, principal stresses and strains, Mohr's circle for stress and strain, theories of failure. Yield, fatigue and creep. Virtual work and associated energy theorems. Deflection and stresses, thin and thick curved bars, thin walled pressure vessels, thick cylinders. Photoelasticity. Strain gauges.

Analysis of statically indeterminate beams: double integration method, superposition method, virtual work, compatibility and equilibrium methods.

Recommended Books

1. Mechanics of Materials by F.P. Beer, E.R. Johnston.
2. Mechanics of Engineering Materials by P.P. Benham & R.J. Crawford.
3. Strength of Materials (Vol. 1-2), Advanced Theory & Applications by J. Alexander & J.S. Gunasekra.

6. Mechanics of Machines-I (Contact Hours/Week (2,2))

Friction between unlubricated surfaces, motion on inclined plane, screw threads and efficiency, friction of pivot, collar and conical bearings, cone, plate and centrifugal clutch, belts and rope drives, chains and sprockets, bands and shoe brakes. Dead weight and spring loaded governors, effort and power, sensitivity, controlling force and stability. Gyroscope, gyroscopic stabilization. Geometry of gears, conditions for transmission of constant velocity ratio, velocity of sliding, path of contact, arc of contact, interference, simple and compound gear trains, epicyclic trains, compound epicyclic trains, torque on gear trains. Theory and applications of dynamometers.

Recommended Books

1. Mechanism Design Vol. 1 by Erdman and Sanders.
2. Theory of Machines by J.E. Shigley
3. Design of Machinery by R. Norton.

7. Mechanics of Machines-II (Contact Hours/Week:(2,2))

Dynamics of engine mechanism/slider-crank mechanism. Velocity and acceleration of piston, angular velocity, acceleration. Forces and couples transmitted in a direct acting engine, velocity and acceleration diagrams, turning moment diagram, fluctuation of energy and speed. Flywheels, valve diagrams and valve gears, steering gears. Types of cams and followers, motion for a given cam profile. Balancing of rotating and reciprocating masses, balancing of in-line engines, V-engines, radial engines, balancing machines.

Recommended Books

1. Mechanism Design Vol. 1 by Erdman and Sanders.
2. Principles of Mechanisms by F. Dyson
3. Theory of Machines by W.G. Green
4. Theory of Machines by J.E. Shigley

8. Machine Design-I (Contact Hours/Week:(2,0))

Basic criteria of the performance and design of machine parts, determination of permissible and actual stresses, design of simple elements, design of keys, cotters, and couplings. Design of welded, riveted and bolted joints. Design of translation screws. Metal fits, tolerances, standards of fits & tolerances, e.g. ISO standards, surface finish.

Recommended Books

1. Mechanical Engineering Design by J.E. Shigley
2. Machine Design, An Integrated Approach by R L Norton

9. Machine Design-II (Contact Hours/Week (2,0))

Stress concentration. Design of spur, helical, bevel & worm gears, design of rolling contact bearings, design of journal bearings, design of mechanical springs, design of shafts.

Recommended Books

1. Mechanical Engineering Design by J.E. Shigley
2. Mechanical Design, An Integrated Approach by R L Norton
3. Design of Machine Elements by M.F. Spotts

10. CAD/CAM Laboratory (Contact Hours/Week (0,4))

Students will learn to use commercial packages on Computer-Aided Drafting (e.g., AutoCAD), Solid Modelling (e.g., Pro-E), and Finite Element Analysis (e.g., ANSYS).

11. Measurement and Instrumentation Contact Hours/Week (2,2)

Significance of measurement, planning of experiments, general measurement system, calibration, static and dynamic measurement sensitivity, range, accuracy precision, repeatability, and uncertainty of instruments, measurement errors.

Instruments for measurement of length, force, torque, frequency, pressure, flow and temperature.

Introduction to data acquisition through computers. A/D and D/A converters.

Recommended Books

1. Measurement Systems Applications and Design, by E. Doeblin, McGraw Hill
2. Theory and Design for Mechanical Measurements, by R. Figliola, And D. Beasley, John Wiley.

12. Control Engineering Contact Hours/Week (2,2)

Basic Concepts. System, control system, input, output, open-loop and closed-loop control systems, elements of a general control system, examples of control system.

Mathematical Modeling of Physical System. Free body diagram and Newton's law of motion, operational notation, grounded chair representation, series-parallel laws, equations of motion for spring mass damper systems, levered system, rotational system, geared system, electrical components and R.L.C circuits, electrical analogies for mechanical systems, scale factors, thermal systems and fluid system.

Transfer Functions and Systems Response. Review of Laplace transform, impulse, step and ramp functions, concept of transfer functions of common components, block diagram algebra, signal flow graphs, impulse, step, and ramp response of first and second order systems, characterization of response (time constant, gain, overshoot, rise time, setting time, steady state error, etc.) relation of system response to location of system poles and zeros.

Stability of Control System. Concept of stability, Routh Hurwitz criterion.

Root locus Methods and its Use in Control System Design

Introduction to Digital Control

Recommended Books

1. Automatic Control, by Francis H. Raven
2. Modern Control System, by Richard C. Dorf
3. Automatic Control, by J.J Distofano et al.
4. Automatic Control Systems, by B. B. Kuo

13. Engineering Materials. (Contact Hours/Week:(2,2))

Metals

Structure of Metals Crystalline structure of metals, allotropy. Crystallographic planes, mechanisms in metals, slip and slip systems, dislocation, twinning, yield phenomenon and strain aging, Bauchinger effect.

Metals and Alloy Systems. Production of iron, wrought iron, cast iron. Production of steel and its classification, ferrite, austenite, S-iron, cementite, pearlite, martensite, bainite, etc. Iron-carbon phase diagram, alloying elements and their effect on the properties of alloy steel. Refining of copper, aluminum and zinc. Aluminum alloys, zinc alloys, copper alloys, brass and bronzes. Metals and alloys for special application. Corrosion of metals anti-corrosive coatings and paints.

Material Forms and Designation. Heat treatment critical temp, transformation on heating/cooling, annealing, normalizing, tempering, quenching, austempering, hardening, rolling processes and production of various steel sections such a billet, bar, rod, channel, Roll load calculation, British standards and ASTM standard specification on iron/steel.

Non Metals

Composition, properties and users of plastics, rubber, ceramics, fiberglass, composite materials and polymers.

Polymers. Molecular structure, bonding & classification of polymer compounding, forming operations etc, plastics.

Ceramics and Refractories. Ceramic bonding, properties, ceramics material, crystalline and amorphous, silica, tetrahedra, glass etc, refractory materials and their types.

Introduction to Composite Materials.

Recommended Books

1. Materials and Processes in Manufacturing by E.P Degarmo

2. Process and Materials of Manufacturing by Lindberg

3. Ceramic Science for Materials Technologist by T.J McCalm

4. Engineering with polymers by P.C. Powell

5. Material Science by Smith

6. Material Science by David Collister

14. Workshop Practice (Contact Hours/Week (0,3))

Fitter Shop. Assembly/disassembly of basic mechanical components, e.g. bearings, keys, belts, etc.

Basic Processes in Wood Work Shop. Timber, its defects and preservation methods, different types of wood joints, making a small wooden model.

Basics of Electric Shop. Types and uses of cables. Study of household electrical appliances.

Functions of Forge & Foundry Shop. Brief introduction, tools and accessories, furnace types, heat treatment furnaces.

Machine Shop. Introduction to machine tools, basic lathe operations including turning, facing, screw cutting.

Welding. Introduction to soldering, brazing and welding, brief details of gas, and electric arc welding.

Students will be assigned practical jobs in machine shop, electrical shop, fitting shop, carpentry shop and smithy shop.

Recommended Books

1. Workshop Technology Part-I by W.A.J. Chapman.

2. Electrical Wiring by Richter and Schwan

3. Wiring Manual by Pak Cables Limited.

15. Manufacturing Processes-I (Contact Hours/Week (2,2))

Forming & Shaping Processes and Equipment. Rolling. Flat rolling, rolling mills, shapes rolling, production of seam less tubing and piping. Extrusion and Drawing. Hot and cold extrusion, Extrusion and drawing equipment, Hydrostatic extrusion.

Sheet Metal Forming. Sheet metal characteristics, formability of sheet metals, bending sheet and plate, tube bending & forming, deep drawing, supper plastic forming, explosive forming, equipment for sheet metal forming.

Forming & Shaping Plastics & Composite Materials. Extrusion, injection molding, blow molding, thermo-forming, processing elastomers, processing reinforcer plastics, manufacturing honeycomb material, processing metal matrix and ceramic matrix composites.

Joining Process & Equipment. Fusion welding process: Oxy-fuel gas welding, arc welding, electrodes, thermite welding, electron beam welding. Solid State welding process: Cold welding, ultrasonic welding, friction welding, resistance welding. Weld quality weldability, weld design and process selection, brazing, soldering, adhesive bonding, joining plastics.

Jigs & Fixtures. General design principle, elements of jig, locating devices and clamping devices.

Metal Casting Process & Equipment. Molding and molding sands, classification of foundry process, casting and its types, pattern and pattern making, core and core making, furnaces, crucibles, molding tools and foundry equipment.

Recommended Books

1. Fundamentals of Modern Manufacturing by Groover
2. Manufacturing Engineering and Technology by Kalpakjian
3. Materials and Processes in Manufacturing by E.P Degarmo
4. Process and Materials of manufacture by F.A Lindberg.
5. Introduction to Manufacturing Process by John Aschey.
6. Manufacturing Process by B.H Amstead, P.F Ostwald.
7. Manufacturing Technology by M.L Begeman, Hazel Hurst.

16. Manufacturing Processes-II (Contact Hours/Week (2,2))

Material Removal. Machines of chips formation, types of chips produced, forces and pressures involved, surface finishing and integrity, machinability. Calculation of material removal rate.

Cutting Tools. Single point tool geometry, mill cutters, factors which affect tool life, tool life relationships, tool materials, types and properties of cutting fluids.

Machine Processes for Producing Various Shapes. Milling operation, milling machines, planning and shaping, broaching and broaching machines, gear manufacturing by machining.

Abrasive Machining & Finishing Operations. Abrasive, bonded abrasives (grinding wheels), grinding process, grinding fluids, design considerations for grinding, ultrasonic machining.

Non Conventional Machining Process. Machining, electrochemical, electrical – discharge machining, wire E D M

Control of Machine Tools. Machine tools control, numerical control system, sequence control, PLC, servo copying, Computerized Numerical Control.(CNC), adaptive control, programming for numerical control

Computer Integrated Manufacturing System. Manufacturing system, Computer Integrated Manufacturing (CIM), Computer Aided Manufacturing (CAM), computer simulation of manufacturing process and system, group technology, Flexible Manufacturing System (FMS), Artificial Intelligence (AI), Cellular manufacturing.

Powder Metallurgy. Production of metal powders, compaction, sintering, design considerations.

Surface Treatment, Coating and Cleaning. Mechanical surface treatment and coating, painting and its testing, thermal spraying, vapor deposition, electroplating and electro forming, anodizing, hot dipping, surface texturing and cleaning.

Introduction to Process Planning

Recommended Books

1. Manufacturing Engineering and Technology by Kalpakjian.
2. Process and materials of manufacture by R.A Lindberg
3. Principle of Engineering Production by AJ Lissaman & SJ Martin.
4. Manufacturing Technology by Hazel Hurst.
5. Engineering Metallurgy by R.A Higgins
6. Manufacturing Science by Gosh and Malik

17. Industrial Management & Economics (Contact Hours/Week (2,0))

Plant Management

The production and services systems inputs and output, management concepts and history. Management systems Role & functions of management. Factors affecting industrial development, industrial development of Pakistan, organization structures & types. Productivity, basic concepts, classification, measurement and improvement. Role of work study, work measurement and work sampling.

Plant location criteria, equipment and utilities layout, types of layout. Material handling systems. Types of production, group technology, variety control, make or buy decisions. Demand forecasting, useful forecasting models, material requirement planning, capacity requirement planning MRP-II. Inventory models and Just in time (JIT) technique, production planning, scheduling problems & models, project management PERT-CPM, network scheduling, activity crashing and resource leveling.

Engineering Economics

Types of Costs. Direct, Indirect, Overheads, Fixed, Variable, Opportunity, Sunk. Cash flow diagrams, time value of money, discounted cash flows.

Equivalence. Present worth, annual equivalent costs, internal rate of return. Payback period. Project feasibility analysis.

Types of investments. Equity vs. debt financing.

Depreciation accounting. Straight line, declining balance and sum of year digits. Plant replacement analysis. Types of taxes. After tax economic analysis.

Inflation and Economic Considerations. Cost estimating methods. Project cost control. Financial management and accounting methods. Case studies in process industries.

Human Resources Management. Recruitment process, job evaluation, performance appraisal, non financial & financial incentives, training, labor relations & industrial safety. Company and industrial laws.

Recommended Books

1. Production & Operations Management by Evert E.Adam Jr and Ronald.
2. Analysis & Control of Production Systems by Elsayed & Boucher.
3. Production Management by Kieth & Loekyer.
4. Company Ordinance, 1984
5. Engineering Economy (7^{th} Ed.) by G.J Thuesen & W.J. Fabrycky. (Prentice)
6. Engineering Economy by DeGarmo.
7. Engineering Economy by White (National Book Foundation)

18. Applied Thermodynamics-I (Contact Hours/Week (2,2))

Basics of Thermodynamics. The system, working substance, heat and work, state and properties, temperature scales, processes and cycles. PV diagram, Internal energy, specific heats. Ideal gas laws, equations of state, first law of thermodynamics, system and control volume concept. Application of conservation of energy principle to isobaric, isochoric, isothermal, adiabatic, isentropic and polytropic processes. Second law of thermodynamics and its consequences, reversibility. Heat engines, thermal efficiency of reversible and irreversible engines, the Carnot cycle. Concept of entropy and its application to flow- and non-flow processes. Available and unavailable energy, isentropic process, enthalpy-entropy diagram.

Physical Properties of Steam. The formation of steam, the triple point, quality of steam, sub-cooled liquid, enthalpy of steam, steam tables, PV diagram for steam, the critical point, behavior of vapor in different thermodynamic processes.

Air Standard Cycles. Carnot, Otto, Diesel, Dual, Brayton, Ericsson, Stirling cycles and their applications.

Vapor Cycles. The reversed Carnot, regenerative, reheat and binary vapor, refrigeration system, Rankine, vapour compression and Stirling cycles.

Recommended Books

1. Fundamentals of Thermodynamics by Moran and Shapiro
2. Thermodynamics, An Engineering Approach by Y.A. Cengel and M.A. Boles
3. Fundamentals of Thermodynamics by Van Wylen and Sontagg.

19. Applied Thermodynamics –II (Contact Hours/Week (2,2))

Properties of Mixtures. Application of Dalton's law and the Gibbs Dalton law, volumetric analysis of gas mixtures, molar mixture and specific gas constants, specific heat Operation of a gas mixture, adiabatic mixture of perfect gases. Psychrometry.

Boilers. Working principles, classification and configuration of boilers. Boiler efficiencies.

Steam Engines. Classification and working principles.

Steam Nozzles and related flow equations

Steam Turbine. Classification and working principles. Efficiency.

Compressors. Classification and working principles, single stage and multistage compressors, intercooling, efficiencies, indicator diagrams, velocity diagrams. Comparison of performance.

Recommended Books:

1. Fundamentals of Thermodynamics by Moran and Shapiro
2. Thermodynamics, An Engineering Approach by Y.A. Gengel and M.A. Boles
3. Fundamentals of Thermodynamics by Van Wylen and Sontagg

20. Fluid Mechanics-I (Contact Hours/Week (2,2))

Properties of Fluids

Fluid Statics. Pressure and pressure gradient, manometry and Bourdon gauge, hydrostatic pressure, forces on plane and curved surfaces, buoyancy and stability.

Integral Relations for a Control Volume. Reynolds transport theorem. Bernoulli's theorem, Integral conservation equations of mass, linear momentum, angular momentum and energy, Impact of jets on curved surfaces.

Differential Relations for a Fluid Particle. Differential equations of mass, linear momentum, angular momentum and energy conservation. Navier Stokes equation, Potential flow theory, stream function, vorticity and irrotationality. Simple flow nets and application.

Dimensional Analysis, Similitude and its Applications

Viscous flow in ducts. Steady, quasi-steady and unsteady flow, under-developed and fully developed, laminar and turbulent flow, flow between parallel plates, flow in tubes, losses in pipes, Moody's chart and pumping power.

Fluid Meters. Piezometer, Pitot tubes, orifice plate, venturi meter, rotameter, etc.

Recommended Books

1. Fluid Mechanics by F.M. White, McGraw Hill, 1994
2. Fluid Mechanics by Shames McGraw Hill.
3. Fundamentals of Fluid Mechanics by Munson, Young & Okiishi

21. Fluid Mechanics-II (Contact Hours/Week (2,2))

Boundary Layer Flow. Boundary layer equations, flat plate boundary layer, effect of pressure gradient, separation and wake, lift and drag of immersed bodies. Airfoil theory; numerical analysis.

Flow through open channels. Uniform flow, Chezy's Bazin's, Kutter's & Manning's formula. Specific energy, hydraulic jump.

Compressible Flow. Adiabatic isentropic steady flow, converging and diverging flow.

Introduction to CFD

Hydraulic Machinery

Introduction to hydraulic system, hydraulic fluids, hydraulic circuits, actuators. Hydraulic pumps and motors, their performance characteristics, efficiency and simulating laws. Impulse and reaction turbines, hydraulic press, hydraulic lifts, hydraulic jack, hydraulic cranes, hydraulic accumulators, and intensifiers, hydraulic couplings, hydraulic ram. Hydraulic systems of earth-moving machinery.

Recommended Books

1. Fluid Mechanics by F.M. White, McGraw Hill, 1994
2. Fluid Mechanics by Shames McGraw Hill.
3. Fundamentals of Fluid Mechanics by Munson, Young & Okiishi

22. Heat & Mass Transfer. (Contact Hours/Week:(2,2))

Introduction. Fundamental equations, relation to thermodynamics.

Conduction. Conduction through plane and composite walls, cylinders and spheres with and without heat generating sources, heat transfer from extended surfaces, transient condition, heat transfer by lumped capacity method.

Convection. The convection boundary layer, the velocity and thermal boundary layer in laminar and turbulent flow over a flat plate. Internal flow through pipes. Dimensionless numbers. Reynolds analysis, shear stress, friction coefficient for fully developed flow. Free and forced convection, empirical correlations.

Mass Transfer. Diffusional mass transfer. General equation of molar flux; applications. Forced convection mass transfer; Analogy between momentum, heat and mass transfer; *f*-factors.

Radiation. Radiation intensity, its relation to emission, black body radiation, absorbtivity, reflectivity, transmissivity. Wien's displacement law, the Stefan-

Boltzman law, Kirchoff's law, the gray body, radiation exchange between surfaces, the view factor, black body radiation exchange, radiation exchange between gray bodies, infinite planes and cylinders.

Heat Exchangers. Types, the overall heat transfer co-efficient, log mean temperature difference, parallel flow and counter flow heat exchanger, multi pass and cross flow heat exchanger, the effective NTU relations.

Boiling and Condensation. Boiling curve for pool boiling; condensation over vertical plates; empirical correlations.

Recommended Books

1. Fundamentals of Heat and Mass Transfer by Incropera & Dewitt
2. Heat Transfer, A Practical Approach by Y.A. Cengel
3. Heat Transfer by J. P. Holman

23. I.C. Engines (Contact Hours/Week (2,2))

Classification, configuration and working principles of IC Engines.

Analysis of Intake and Exhaust. Measurement of fuel and air consumption, volumetric efficiency, super-charging, effect of air-fuel ratio and compression-ratio on engine power & efficiency, pumping work, effect of residual gases on intake temperature, injection of fuel, carburetors/fuel injector, ignition system development, exhaust gas analysis and air pollution, control of exhaust gas contents, energy emissions.

Fuels and Combustion. Gasoline characteristics, alcohol refining and octane & cetane rating, diesel fuel oil classification, gas turbine & jet fuel, additives, combustion equation, CNG. Theoretical flame temperature, reaction rate and flame propagation, methods of igniting fuel, auto ignition, knock and the engine variable detonation, combustion theories, ignition delay, chemical equilibrium and dissociation, energy charts for unburned air mixtures, stratified charge engine, combustion chamber requirement.

Lubricants. Engine lubrication systems, additives for lubricants.

Engine Characteristics. Valve timing, torque & mean effective pressure, comparison of real cycles with the ideal cycle, indicated power, brake power, specific fuel consumption, heat balance sheet, relation between indicated thermal efficiency and load, SI & CI engines comparison, speed and load control in SI & CI engine, high output engines, turbocharged engines.

Recommended Books

1. Internal Combustion Engine Fundamentals by J.B. Heywood
2. Internal Combustion Engines by C.R. Ferguson
3. Introduction to I. C. Engines by Richard Stone
4. Internal Combustion Engines by O.F. Obert

24. Power Plants (Contact Hours/Week:(2,2))

Steam Power Plants. General layout of modern steam plants, steam generators, engines and auxiliary components, back pressure and passout turbines. Deviation of actual cycle from ideal cycle, losses in pipes, turbine, pump and condenser.

Gas Turbine Power Plant. Development and improvement on gas turbine, the practical gas turbine cycle, modification of the basic cycle. Isentropic efficiency of compressors and turbines, intercooling & reheating. Hydro process plants basic classification and efficiency.

Jet Propulsion Plant. Aircraft jet engine, efficiency and performance of turbojet plant, ram jet and pulse jet, subsonic and supersonic propulsion, performance of rocket vehicles, propellants and combustion, thrust chamber.

Introduction to Hydel Power Plants. Low and high-head power plants.

Nuclear Power Plants. Introduction, nuclear reactions as energy sources, components of nuclear plants. Fissions process self sustaining chain reaction, moderators and reflectors. Classification of thermal reactor, instrumentation, nuclear hazards and safety practice.

Introduction to Solar Power Plants and other emerging technologies.

Comparison. Comparison of steam, gas, hydel , jet and nuclear power plants with special reference to the availability of fuel for these plants. Economic Analysis of Power Plants. Plant selection and performance characteristics.

Recommended Books

1. Power Plant Technology by M. M. El Wakil
2. Power plant by F.T. Morse
3. Applied Thermodynamics for Engineering Technologist by T. D. Eastop & J McConkey

25. Computer Systems and Programming (Hours/Week (1,3))

Introduction to Computers. Computer components and systems, Networks, Operating Systems. Word Processing, Spreadsheets, Presentation software, Internet Browsers & E-mail.

Programming in C or Visual Basic.

Introduction to MATLAB

26. Electrical Engineering (Contact Hours/Week (2,2))

Introduction to DC Circuits: Series and parallel circuits, DC circuit analysis.

Theory of Alternating Current. Series and parallel circuits, resistance, inductance and capacitance of AC circuits, power factor, resonance in RLC circuits, single phase and polyphase circuits. Power and power factor measurement, current and voltage relationship in phase and line circuits. Types, characteristics and testing of AC motors, motor starters and switch gears, electric traction and braking, solenoids.

Transformers. Voltage and current relationship of primary and secondary types of transformers, losses and efficiency.

Generators and motors. Types, construction and characteristics. Motor starters. Testing and efficiency of machines.

Recommended Books

1. Electric Circuits, Basic Electricity by Schaum's Series
2. Electric Machinery Fundamentals by S. Chapman
3. Electrical Power Technology by Theodore Wildi

27. Electronics: (Contact Hours/Week (2,2))

Part-1 (25%).

Semiconductors, rectifiers, transistors, relays, Operational Amplifiers.

Part-2 (75%)

Number systems, Boolean Algebra, gates. Combinational logic (adders, comparators, decoders, multiplexers, etc.) Sequential logic (flip-flops, registers, counters, ROM, PROM, EPROM). Microprocessors (registers; ALU; CU; memory, address, data and control buses). ADC and DAC. Micro-controllers.

Recommended Books

1. Electronic Devices, by Floyd, Prentice Hall
2. Electronic Principles by Malvino, A.Paul McGraw Hill
3. Digital Computer Electronics, by Malvino , McGraw Hill.

28. Applied Mathematics-I (Contact Hours/Week (2,0))

Complex numbers, Argand diagram, De Moivre's theorem, hyperbolic and inverse hyperbolic functions. Algebra of vectors and matrices, systems of linear equations.

Derivative as slope, as rate of change (graphical representation). Extreme values, tangents and normals, curvature and radius of curvature. Differentiation as approximation. Partial derivatives and their application to extreme values and approximation.

Integration by substitution and by parts, integration and definite integration as area under curve (graphical representation). Reduction formulae. Double integration and their applications.

Polar and Cartesian coordinates, polar curves, radius of curvature, cycloid, hypocycloid, epicycloid and involute of a circle.

Recommended Books:

1. Calculus and Analytic Geometry by Thomas Finney
2. Advanced Engineering Mathematics by C. R. Wylie
3. Engineering Mathematics by Erwin Kreszig

29. Applied Mathematics –II (Contact Hours/Week:(2,0))

Differential equation; basic concepts and ideas; geometrical interpretation of first and second order differential equations; separable equations, equations reducible to separable form, exact differential equations, integrated factors. Linear first differential equations, Bernoulli's differential equations. Families of curves, orthogonal trajectories and applications of differential equations of first order to relevant engineering systems.

Homogeneous linear differential equations of second order, homogeneous equations with constant coefficients, the general solutions, initial and boundary value problems, D-operator, complementary functions and particular integrals. Real, complex and repeated roots of characteristics equations. Cauchy equation, non-homogeneous linear equations. Applications of higher linear differential equations to engineering systems.

Ordinary and regularly points and corresponding series solutions; Legendre's equations and Legendre's polynomial, Bessel equations and Bessel function of first kind.

Partial differential equations and their solutions by separable variables. Applications of partial differential equations.

Differentiation and integration of vectors, curl, gradient and divergence; Green's and Stoke's theorem.

Recommended Books

1. Advanced Engineering Mathematics by C.R. Wylie
2. Engineering Mathematics by Erwin Kreszig

30. Applied Mathematics - III (Contact Hours/Week (2,2))

Laplace Transform. Laplace transform of elementary functions; Laplace transform theorems, inverse Laplace transform, applications to the solutions of ordinary differential equations.

Fourier Series. Fourier theorem and coefficients in Fourier series, even and odd functions, complex form of Fourier series.

Fourier Transform.

Numerical Analysis

Difference Tables and construction of polynomials. Solution of simultaneous equations by Cramer's rule and LUD decomposition. Solution of equations by iterative methods. Numerical differentiation and integration, with applications. Eigenvalues and Eigenvectors.

Practical exercises will be assigned to prepare computer programs for numerical analysis techniques.

Recommended Books

1. Advanced Engineering Mathematics, by Erwin Kreyszig
2. Elements of Differential Equations, by Keplan. W.
3. Mathematical Methods, by S. M. Yousuf

31. Engineering Statistics. (Contact Hours/Week (2,0))

Treatment of Data. Frequency distributions and graphs. Measures of central tendency. Variance, standard deviation.

Probability. Samples spaces and events, counting probability. Elementary theorems,. Conditional probability. Bay's theorem. Mathematical expectation and decision making.

Probability Distribution. Random variables. Binomials Distribution. Poisson processes. Probability densities. Normal distribution, Statents "t" Distribution. Chi-square Distribution.

Sampling Distribution. Populations and samples. The sampling distribution of the mean (known and unknown). The sampling distribution of the variance.

Curve Fitting. Regression analysis by least square methods. Correlation linear, polynomial, power, Regression analysis by least square methods incorporating linear, polynomial, exponential or power function. Correlation coefficient determination.

Design of experiments. Taguchi method. **Control Charts**

Recommended Books

1. Probability for Engineers, by Irwin Miller, John E Freund

2. Statistical methods for Engineering & Scientists, by Walpol & Meyers

3. Introduction to statistics, by Iqbal Bhatti

4. Introduction to statistics Theory-I, by Sher Mohammad

5. Modern Probability by Parezen E.

32. Islamic and Pakistan Studies/Ethics: (Contact Hours (2,0))
As recommended by HEC

33. English: (Contact Hours (2,0))
As recommended by HEC for BSc.

34. Technical Writing and Presentation Skills (Contact Hours (2,0))
To prepare the students for academic reading, writing, oral presentation, reference skills and grammar. The students shall be given practice in communication skills and introduced to the principle of effective writing from the sentence level to full length text with emphasis on logical organization of materials. Writing technical reports, feasibility reports, and proposals. Oral communication is improved through class Seminars.

Recommended Books

1. Technical Writing Today by Pauley and Riordan

35. Final Year Project (Contact Hours (0,6))

ELECTIVE COURSES

1. Mechanical Vibrations. Contact Hours/Week :(2,2)

Oscillatory motion. Harmonic motion, periodic motion, vibration terminology.

Free vibrations. Equation of motion, energy method, viscously damped free vibration, logarithmic decrement, harmonically excited vibration, forced harmonic vibration, vibration isolation, vibration measuring instruments.

Two degree of freedom system. Normal modes of vibration, coordinate coupling, forced harmonic vibration, vibration absorber, vibration damper. Orthogonality.

Vibration of Elastic Bodies. Free and forced vibration of cables and uniform bars, free and forced lateral vibrations of simply supported thin beams, torsional vibration of circular shafts with single rotor and two rotors, critical speed of rotating shafts.

Finding natural frequencies: Rayliegh method and Holzer method.

Measurement of Vibrations.

Recommended Books

1. Mechanical Vibrations : Theory & Applications by W.T. Thompson
2. Mechanical Vibrations by S. S. Rao.
3. Elements Of Vibration Analysis by L. Meirovitch, McGraw Hill

2. Refrigeration & Air-conditioning. (Contact Hours/Week (2,2))

Reverse Carnot cycle, the vapor-compression cycles, coefficient of performance, introduction to pressure-enthalpy charts. Refrigerants. Components of a refrigerating system, leakage, domestic and commercial applications. Air cycle refrigeration, Steam jet refrigeration, Vapor absorption refrigeration, Low-temperature refrigeration and their applications. Psychometry, basic air-conditioning processes, load calculation, systems of air conditionings, humidification & economics of system dehumidification, humidifiers, air distribution systems, insulation materials. Industrial air-conditioning.

Recommended Books

1. Refrigeration and Air Conditioning by : W.F. Stoecker & Jones
2. Refrigeration and Air Conditioning by K. L. Dossat
3. Refrigeration and Air-conditioning by Arora

3. Energy Resources & Utilization(Contact Hours/Week (2,2))

Energy resources, renewable resources, environmental impact**,** energy analysis, energy and economics, energy and society, energy and environment, energy planning , energy conservation.

Recommended Books

1. Energy Efficiency For Engineers and Technologists by Eastop and Craft.
2. Energy Resources in Muslim Countries by M. Masud Butt.

4. Gas Dynamics ((Contact Hours/Week (2,2))

Basic governing laws of conservation of mass, momentum and energy, limitations. Sub-sonic and supersonic gas flow. Mach number and Mach angle.

Isentropic Flow and Applications; Operation of nozzles under varying pressure ratios. Normal and oblique shocks, Prandtyl-Meyer compression and expansion with applications.

Flow in ducts with friction and heat transfer.

Recommended Books

1. Gas Dynamics, by M.J. Zucrow and J.D. Hoffman, Wiley, 1976.
2. The Dynamics and Thermodynamics of Compressible Fluid Flow (Volume 1), by A.H. Shapiro, Ronald, 1953.
3. Gas Dynamics, by J.E. John, Allyn and Bacon, 1984.

5. Aerodynamics: (Contact Hours/Week: (2,2))

Introduction, compressible and ideal fluid flow, airfoils, aircraft propellers, jet propulsion, aircraft performance, measurement.

Recommended Books

1. Aerodynamics for Engineering Students, by El. Houghton & A. E. Brock St Mortin
2. Aerodynamics, by L. J. Clancy, Hallstead Pr.

6. Steam and Gas Turbines (Contact Hours/Week: (2, 2))

STEAM TURBINES

Review of relevant topics.

Steam Turbines. Impulse and reaction turbines, Compounding, Classification of turbines, Internal losses, State point locus and reheat factor.

Combined Heat and Power Plants. Extraction and back pressure turbines. Turbine performance and controls. Feed water heater, air pre-heater, economizer, super-heater. Plant efficiencies and their improvement.

GAS TURBINES

Review of relevant topics.

Working Cycles: Effect of pressures, temperatures, and component efficiency on fuel and air consumption and power of the simple plant. Inter-cooling, reheat and heat exchanger cycles. Industrial open and closed plant.

Gas Turbine Cycles for Aircraft Propulsion. Turboprop, Turbofan and Turbojet engines, influence of altitude and flight speed on performance.

Centrifugal Compressors. Principle of operation. Work done and pressure rise. Compressibility effects. Non-dimensional quantities for plotting compressor characteristics.

Axial flow Compressors. Elementary theory, degree of reaction, simple design method, blade design, calculation of stage performance, overall performance, compressibility effect.

Combustion System. Forms of combustion system, some important factors affecting combustion chamber designing, combustion process, combustion chamber performance.

Axial Flow Turbine. Elementary theory, vortex theory, choice of blade profile, pitch and chord, estimation of stage performance, overall turbine performance.

Prediction of performance of Simple Gas Turbines. Component characteristic, off design operation of single shaft turbine, equilibrium running of a gas generator, off design operation of free-turbine engine, jet engine.

Recommended Books

1. Power Plant Technology, by M.M. El Wakil
2. Steam Turbines Theory and Practice, by W.J. Keartin
3. Gas Turbine Theory and Practice, by Cohen, Rogers, and Saranvanamuttoo.

7. Manufacturing Automation (Contact Hours/Week: (2,2))

Automation. Introduction, arguments in favour and against automation, types of automation, strategies, economics of automation, flow lines, mathematical models, storage buffers, partial automation, balancing, group technology and flexible manufacturing.

Hardware of Automation. Sensors, analyzers, actuators, drives, robotics geometry, drives and motion control, uses and justification of CNC machining, advantages, machine code, machine control, programming, DNC, CNC.

Logic Controllers. Truth tables, Boolean algebra, logic diagrams, response diagrams, PLC and programming.

Recommended Books

1. Automation, Production Systems, and CAM by M. P. Groover. (Prentice Hall)
2. Robotics & Manufacturing Automation (2nd Ed.) by C. R. Asfahl. (John Wiley)
3. Computer Control of Machines and Processes by Bollinger and Duffie
4. Handbook of Industrial Engineering (2nd Ed.) by G. Salvendy.(John Wiley)

8. Maintenance Engineering (Contact Hours/Week: (2,0))

Introduction and types: Preventive maintenance, its objectives, benefits and economics, inspection and implementation. Routine maintenance and monitoring of fault indicators, main concepts and implementation. Proper assembly/disassembly, alignment aspects, machine handling. Record keeping and maintenance scheduling, stocking spares and cost effectiveness, safety in maintenance. Basic repairs of electro-mechanical equipment, fault diagnosis and assessment. Introduction to predictive maintenance.

Basic Repairs. Replacement/refurbishment of defectiveness parts e.g. bearings, brakes, shafts.

Recommended Books

1. Maintenance Engineering Handbook by L.R. Higgins, L.C. Morrow, McGraw-Hill
2. Management Handbook for Plant Engineers by B.J. Lewis, McGraw-Hill

9. Quality Engineering (Contact Hours/Week: (2,0)

Defect identification vs. prevention, Models of Quality Assurance; Artisan Production Model, Inspection Production Model, Sampling Production Model, Process Control Model, Quality Error Prevention Model. Quality Assurance Assessment. Introduction to Total Quality Management. QC Circles. Taguchi's Model. Quality System Standards. ISO Quality models.

Inspection and Gauging

Line and end standards, Linear measurements, Interferometry, Taylor theory of gauging, System of Limits & Fits, B.S. 4500, Angular measurements; Sine bar, Angle gages, Autocollimator, Comparators: Mechanical, Electrical, Optical. Surface Texture.

Statistical Quality Control

Use of Binomial, Poisson and Normal Distributions, Sampling plans; Single, double and multiple Control Charts, Inspection by Attributes, Inspection by Variables, Reliability & Maintainability.

Introduction to Total Quality Management. Kaizen and 5□ Techniques.

Recommended Books

1. Handbook of Industrial Engineering (2nd Ed.) by G. Salvendy.
2. Metrology For Engineers by Galyer and Shotbolt
3. Total Quality Control by A.V. Feigenbaum.
4. Statistical Quality Control by Grant & Leavenworth

10. Introduction to Mechatronics (Contact Hours/Week: (2,2))

Sensors and transducers, transducer characteristics, sensors for measuring displacement, strain, force, pressure, temperature and motion. Encoders.

Motors and their types. Stepper motors. Permanent magnet DC motors. Servo Systems.

Interfacing. Ports, Input/Output, Analog to Digital converter, sampling theory, Digital to Analog converter. Sample and hold, multiplexer. Interfacing switches, LEDs, stepper motors and DC motors to micro-controllers.

Recommended Books

1. Design with Microprocessors for Mechanical Engineers, by A. K. Stiffler, McGraw Hill.
2. Microprocessor Architecture, Programming and Applications by Goankr, Merril Publishing Co.

11. Robotics and Manufacturing Automation (Contact Hours/Week (2,2))

Introduction to CAD/CAM; its interface and product design. Machine tool control; use of CNC, its elements and types; CNC procedure, CNC part programming; computer aided part programming

Robotics and Automated Guided Vehicles. Robotics definition, terminology, types, robot geometric configuration, basic robot motion, robot systems, path control, robot drive system sensors, robot-computer interface, robot programming, applications, Automated Guided Vehicles (AGV) types.

Computer Aided Process Planning (CAPP) : Introduction to CAPP Systems, Types of CAPP Systems, computer Software for CAPP.

Recommended Books

1. Robotics and Manufacturing Automation by C. R. Asfahd (J. Wiley)
2. Automation Production Systems by M. P. Groover

12. Operations Research (Contact Hours/Week (2,2))

O.R. Techniques and basics, linear programming, graphical method, simplex method, sensitivity and post-optimal analysis, transportation models, networks, CPM & PERT. Queuing theory (weighting live models).

Replacement Models.

Simulation. basic principles, discrete models vs. continuous system simulation, applications, use of digital computer for simulation, languages of simulation, introduction to GPSS (General Purpose System Simulation) language, practical applications of GPSS.

Recommended Books

1. Operations Research , (7^{th} Ed.) by H.A. Taha. (Maxwell Macmillan International)
2. Introduction To Simulation Modelling Using GPSS/PC by .J.A. Chisman.

13. Machine Dissection Practice (Contact Hours/Week: (0, 2)

Disassembly and assembly of common machines e.g. automotive engines, refrigerators , air-conditioners, pumps, motors; to understand materials, design features, manufacture and functions of different components. Dos and don'ts of disassembly and assembly.

14. Tribology (Contact Hours/Week: (2,0))

Friction, wear, and lubrication of sliding and rolling parts. Types of lubricants, grades and their properties; theories of lubrication, Static and hydrodynamic lubrication . Lubrication of mechanical components.

Recommended Books

1. Basic Lubrication Theory , by A Cameron
2. Theory and Practice of Lubrication for Engineers by D.D. Fuller

15. Nuclear Engineering (Contact Hours/Week: (2.0)

Review of nuclear physics, reactor physics, reactor heat transport. Types of nuclear reactors, and power plants. Reactor material . Nuclear fuels, enrichment and reprocessing ; handling of fuels . Safety aspects.

Recommended Books

1. Introduction to Nuclear Engineering by J.P. Lamarsh.
2. Nuclear Power Engineering by M. M. El Wakil .

16. Environmental Engineering (Contact Hours/Week: (2,0))

Introduction: Importance of clean environment, Scale of Environmental Pollution. Environmental Act. Health and Safety Act.

Atmospheric Pollution: Types of Atmospheric Pollution, Their Causes and Effects on Human Health, Available Technologies for Controlling Pollution.

Industrial Waste: Solid Waste, Industrial Effluents and Waste Gases, waste treatment plants.

Noise Pollution: Measurement of Noise level, Effect of excessive noise on human health. Remedial Measures

Environmental Standards: ISO 14000

RECOMMENDATIONS

After thorough discussion of the issues involved, the committee decided to make the following recommendations.

1. The committee emphasized that in order to take full advantage of the new curriculum, efforts should be made to increase the effectiveness of teaching-learning process. For that purpose, the following recommendations are made:

   a. Training of teachers in teaching methodology, increased teacher-industry interaction and regular participation of teachers in relevant conferences must be ensured. Universities should take necessary steps and provide financial resources for that purpose.

   b. The examination system should be improved to ensure that students understand basic concepts and are able to apply the concepts independently, rather than rote learning.

   c. Teaching aids such as white boards and overhead projectors must be provided in all classes.

2. The committee recommends that video libraries should be established at all universities to illustrate engineering processes and techniques that are difficult to understand through books alone. Universities may obtain technical videos from various sources, such as JICA, APO, JETRO, AOTS and ASME and share the resources among themselves as far as possible. Addresses of some of the organizations, provided by the industry, are given below for reference:

   Japan External Trade Organization (JETRO)
   5th Floor, State Life Building No.11,
   Abdullah Haroon Road, Karachi
   Phones: 2449983, 5680729, 5684426

   Association For Overseas Technical Scholarships (AOTS)
   30-1, Senju-azuma 1-chom, Adachi-ku
   Tokyo, 120-8534, Japan
   Fax: 81-3-3888-8242
   http//www.aots.or.jp
   email: information@aots.or.jp

3. An institutional mechanism be developed for facilitating students to obtain internship with various industries and public sector organizations. It is recommended that the Govt. of Pakistan may issue a directive to such industrial organizations, in the form of an SRO. Also, the proposed Board of Governors of the respective universities should

include a representative of the industry mandated to facilitate internships and industrial visits.

4. Universities should arrange short industrial visits of students every year to augment engineering concepts of the students and to enhance their confidence about relevance of engineering subjects to jobs in the field. In this respect, the students must submit a visit report whose evaluation must be incorporated in a relevant subject.

5. To facilitate the provision of high quality and latest text books to the students on affordable prices, it is recommended that:

   a. The books recommended at S.No.1 for each course in the recommended curriculum should be adopted as textbooks by all the universities.

   b. The universities should request National Book Foundation to print these books for use of students. Being printed in large quantities, the books will then be available to students at affordable rates.

   c. To facilitate the provision of teaching materials, such as Power Point presentations and solution manuals, publishers like McGraw Hill (www.mhhe.com) and John Wiley have created instructors resource centres for most of these books, which can be accessed through the internet.

6. In order to regularly update the specific requirement of the local industry, in future, it is imperative that the practice of preparation and implementation of National Five Years Plan be re-introduced, on priority by the Govt. of Pakistan. Based on the outline of technology needed for these schemes and projects, the universities could train students in relevant subjects to be adopted as elective courses.

7. Realizing the increased application of computers in engineering, it is recommended to introduce a new core course on CAD/CAM. Efforts should also be made to integrate the use of computers in other courses, wherever possible.

8. In view of the growing demand by the industry on developing the student's proficiency in English and communication skills, presentation methods, report writing etc., the committee has decided to place the subjects of English and Technical Writing & Presentation Skills as part of core courses.

9. The course of Industrial Management has been strengthened by merging Engineering Economics (which was one of the elective courses) with this course.

10. It is recommended that the course on Maintenance Engineering, although included in elective courses, should be adopted wherever possible, in view of its special relevance to Pakistan's industry.
11. To ensure effective implementation of the curriculum, the list of practicals conducted in various subjects should be documented.

12. The committee deliberated on the Masters program in Mechanical Engineering. It was felt that at this stage standardization of courses is not possible, nor desirable, due to diversity of specialization. However, some recommendations were prepared regarding the basic parameters of the program, which are included below.

Recommendations on the Bachelors in Mechanical Engineering Syllabus

1. The total curriculum should be spread over four (4) academic years or eight (8) academic terms/semesters.

2. The contact hours for theory and practical have been suggested for each course based on the annual system and should be modified suitably for term system. One credit hour is equivalent to one lecture hour or two hours of practical work per week. Furthermore, each credit hour should carry 50 marks. In general, a minimum of 26 lecture hours are recommended for each contact hour per week in the annual system.

3. The total curriculum should cover a set of core courses (essential for mechanical engineering degree), and a set of electives. It is recommended that the core courses should be made mandatory by the universities for all mechanical engineering programs. However, minor deviations in names and contents may be allowed. Any core course may also be split into two to cover more topics. A set of subjects may be chosen from the list of electives to fulfill the complete curriculum requirement. Universities may introduce additional electives depending upon specialization of the faculty and demand of the market. Similarly, the textbooks recommended for the subjects may not be considered mandatory. These books are meant as a guideline only. The proposed core/compulsory courses and elective courses are given in Annex-I and Annex-II respectively. The syllabi of core courses are given in Annex-III and those of elective courses in Annex-IV.

4. A set of at least 36 courses comprising all core subjects and selected elective courses must be completed.

5. Field training is recommended for all engineering students. The duration of this training is recommended to be of about 8 weeks and it may be held during third and final academic year. To increase the effectiveness of the internship program, it is recommended that the universities should take feedback from the industry regarding the performance of internees.

6. The final year project, which is mandatory, should involve design, analysis, and practical work culminating into submission of a formal report.

Recommendations on the Masters in Mechanical Engineering Syllabus

1. The Masters program in Mechanical Engineering should consist of at least 30 credit hours spread over a minimum of three semesters/terms. The duration of each semester/term should be at least 18 weeks.

2. Two options may be offered by a university for the Masters program – Masters by Research and Masters by Coursework Only.

    a. Masters by Research should require 24 credit hours (at least 8 subjects) of coursework and 6 credit hours of research. The committee considers it important that the student should be available full time during the research work.

    b. Masters by Coursework should require at least 30 credit hours (at least 10 subjects) of taught courses.

3. Course work in Masters program must include at least one course each in Mathematics and Computation.

4. The following specializations are being offered currently in Masters program by various universities. Further specializations may be offered as per requirements.

    a. Manufacturing/Production Engineering
    b. Thermal Power Engineering
    c. Fluids & Control Engineering
    d. Design Engineering
    e. Mechatronics Engineering
    f. Engineering Management

(Prof. Dr. Irfan Ullah)
Secretary

(Prof. Dr. Ijaz Ahmad Malik)
Convener