IESL ENGINEERING COURSE - SYLLABI

PART I

Subject No.		List of subjects
101	..	Mathematics
102	..	Presentation of Engineering Information
103	..	Properties and Strength of Materials
104	..	Electro techniques
105	..	Thermodynamics
106	..	Applied Mechanics

(Examinations for the (old) Part I syllabi will be conducted up to March, 2000)

CURRICULA FOR THE IESL PART I

Subjects	No. of Hrs		
	Lectures	Practicals	Additional Practicals *
101. Mathematics	80		
102. Presentation of Engineering information			
I Information	50		
II Engineering Drawing	24	16	
(additional work for specified category)	24	16	
103 Properties and Strength of Materials	80		15
104 Electro techniques			
105. Thermodynamics	80		15
106. Applied Mechanics	80		15

- practicals for those who have had no practicals in the qualifying courses.

(Candidates for the Part I, are expected to offer all six subjects listed above.

101. Mathematics

Lectures = 80 hours

Algebra

Matrices: types of Matrices, algebra of matrices, inversion Determinants: properties of determinants` Adjoint method for inversion of matrices; solution of simultaneous equations; Gauss elimination method; Echelon form; linear dependence and consistency.

06 hrs

Vector algebra in 3-D and applications

07 hrs

Complex numbers; Argand diagram; algebra of complex numbers; De Moivre's theorem; roots of complex numbers Roots of algebraic equations; the remainder theorem.

08 hrs

Analysis

Functions: Limits, continuity; trigonometric, exponential, hyperbolic and logarithmic functions; inverse functions; implicit functions.

Differentiation; Stationary points and curve sketching Mean value theorem; L'Hospital's rule for limits Leibnit's theorem; partial differentiation and applications Infinite series and tests for convergence. Taylor series in one and two variables.

17 hrs

Methods of integration; reduction formulae. Applications of integrals to areas, volumes, moments etc.

08 hrs

Ordinary differential equations; formulation Methods of solution of first order differential equations, second order differential equations with constant coefficients Use of D-operators.

08 hrs

Numerical Methods

Solution of equations in one variable; successive substitution method rule of false position; Newton-Raphson method; solution of simultaneous linear equations; Jacobi method; Gauss-Seidel method

04 hrs

Finite differences and interpolation
Numerical differentiation

06 hrs

Numerical integration; trapezoidal rule; Simpson's rule

04 hrs

Numerical methods of, solution of ordinary differential equations
Euler's method; Euler's modified method; difference equations

06 hrs

RECOMMENDED BOOKS

Advanced Mathematics for Engineers and Scientists by G S Sharma, K L Ahuja and I J S Sarma, CBS Publishers New Delhi.

Schaum's Outline Series books on : Matrices
Linear Algebra
Vector Analysis

Calculus
Advanced Calculus
Differential Equations
Numerical Analysis

First Course in Numerical Analysis by M A A Wolfe, van Nostrand Reinhold Company Ltd.

102 PRESENTATION OF ENGINEERING INFORMATION

Lectures and Practical Classes – 90 hours additional Lecturers and Practical Classes 10 hrs.

Engineering Drawing Practice

(Lectures a, b, c, and practical class "a" are intended for those candidates, who do not posses a basic knowledge in Engineering Drawing. Each set of lectures should be followed by a take home assignment (THA) which need to be market & given to the students. Model answer for the take home assignments should be distributed in the following session. The course will consist of lectures 12 + 3 (each of 2 hrs duration) Practical Classes 4 + 1 (each of 4 hrs duration) Take home assignments 9 + 3. (THA) (Each practical class is of 04 hours duration)

Lecture "a" - Instruments & Materials of drawing, Drawing standards, lines & lettering sizes of drawings, Title blocks etd.

02 hrs

Lecture "b" - Simple geometrical constructions (Bisectors, perpendiculars, divided lines, areas, circles, angles and other useful constructions) (THA)

02 hrs

Lecture "c" - Tangency construction, the properties with the associated constructions of the common plane geometrical figures including conic sections & other loci – (THA)

02 hrs

Practical "a" - Class exercise base don lectures a, b and c. This all be exercise should be marked by the lecturer and the common errors can be discussed at the class to follow.

04 hrs

LECTURE 01

Revision Lecture for both categories of students. The principles of Engineering drawing including basic geometrical constructions (Drawing Standards, Instruments and materials of drawing lines & lettering, Graphic Geometry. The properties with the associated constructions of the common plane geometrical figures including conic sections and other loci) (THA)

02 hrs

LECTURE 02 + 03

Recording and sketching two dimensional drawings. Orthographic drawing and sketching (First angle and third angle projections) (THA)

04 hrs

PRACTICAL CLASS 01

Assignment based on lectures 1, 2 & 3 to be done in the classroom.

04 hrs

LECTURE 04

Sectional views and conventions (Types of Sections, Assembly Sections, Conventional Practices, Auxiliary Views and Sectionsl) (THA)

02 hrs

LECTURE 05 & 06

The preparation of working drawing and freehand sketching in Orthographic and Pictorial Projection of Common Engineering Components and Simple Assemblies, Assembly Drawings Exploded, Exploded Orthographic, scattered orthographic views. (THA)

04 hrs

PRACTICAL CLASS 02

Assignment based on lectures 4, 5 & 6 to be done in the class room.

04 hrs

LECTURE 07

The projection line on inclined and oblique planes, Projecting plane figures, Method of revolution, coincidence and replacement of planes of projections. (THA)

02 hrs

LECTURE 08 & 09

Intersection of planes and interpenetrations of solids. The development of surfaces (THA)

04 hrs

PRACTICAL CLASS 03

Assignment based on lectures 07, 08 & 09 to be done in the class room.

04 hrs

LECTURE 10

Limits, bits and dimensional tolerances, geometrical tolerances, surface finish. (THA)

02 hrs

LECTURE 11

Screwthreads, fasteners, keys, springs & gears. (THA)

02 hrs

LECTURE 12

The drawing system, preparation of working drawing. (THA)

02 hrs

PRACTICAL CLASS 04

Assignment based on lectures 10, 11 & 12 to be done in the class room.

04 hrs

PRESENTATION OF ENGINEERING INFORMATION

Experimental Data

Presentation of experimental data in graphs, monograms, etc.; curve fitting by least square method.

05 hrs

Presentation and use of statistical data: arrays: frequency tables: histograms: frequency polygons: cumulative frequency polygons: mean: median: mode: range: standard deviation.

06 hrs

Use of probability: sample space: events: probability of events: addition law: conditional probability: multiplication law: independence and dependence of events: Bays' theorem: binomial, poisson and normal distributions and applications.

14 hrs

Flow sheets: logic diagrams and networks for process representation: critical path analysis.

05 hrs

Computation

Digital computing: Basic model of a computer: the programme concept: Machine code: assembly language and high level languages: compilers and interpreters.

Writing programmes in a high level language (Fortran, Basic or Pascal): simple flow charts and algorithms: the subroutine concept: data structures and data types: control flow: basic input and output: use of computer graphics.

07 hrs

Spread sheet programmes: entering data: data types: analysing data: presenting data in the form of graphs: Introduction to Computer Aided Design.

06 hrs

Analog computing: block diagrams for solution of differential equations, analog computer components.

RECOMMENDED BOOKS

ENGINEERING DRAWING PRACTICE

1. Sri Lanka standard 409

2. Engineering drawing and design
   CiCil Jensen, Jay D. Helsel ISBN 0-07-032555 – 3
   McGraw – Hill - 1990

3. Engineering Drawing
   S. Bogolyuboy, A. Voinov
   Mir Publishers – Moscow – 1986

PRESENTATION OF ENGINEERING INFORMATION

1. Probability and Statistics for Engineers and Scientists by Ronald E. Walpole and Raymond H. Myres, The Mcmillan Co. Ltd.,

2. Project Network Analysis and Critical Path by A.C. Simme and J.J. Britten, The Machinery Publishing Co. Ltd.,

3. Programming in fortran by S. Srinivasan.

4. Basic BASIC by James S. Coan.

103. PROPERTIES AND STRENGTH OF MATERIALS

Lectures = 80 hours

Stresses & Strains

Stresses (normal & shear) on an inclined plane in a 2D stress system – Formulae for normal and shear stress on inclined plane – Mohr's circle of stress – Invariants of a Mohr's circle – Maximum and Minimum principle stresses – pole of the Mohr's circle – Applications of Mohr's circle and normal/shear stress formulae in analysing stress systems.

Stress/Strain relationships of a 2D system – Young's modulus, shear modulus and Poisson's ration – Normal strain and shear strain – Formulae for normal and shear strain on an inclin4ed plane – Mohr's circle of strain – Stresses from strain gauge data.

08 hrs

Springs.

Close coiled and open coiled helical springs, Flat spiral springs, Leaf springs, Conical springs.

04 hrs

Bending Moments & shear Forces in statically determinate beams

Definition of bending moments and shear forces as internal forces in flexural members – determination of bending moment and shear force at any given section of a beam – Relationship between load, bending moment and shear force – Bending moment and shear force diagrams – Principle of superposition. 06 hrs

Bending Stresses & Shear Stresses in Beams

Sectional properties of beam sections including built – up sections – Definition of neutral surface and neutral axis – classification of bending stress as a direct (normal) stress at a sections – Tensile & compressive stresses – Simple bending formula – Application of simple bending formula – Section modulus – Distribution of bending stress at a section.

Definition of shear stress – Principle of complementary shear – Shear stress formula – Distribution of shear stress at a section.

06 hrs

Deflection of beams

Beam flexure equation for small deflections-Statically indeterminate beams-Maculay Method in applying beam flexure equation-Moment area method.

06 hrs

Torsion of Circular Sections

Shear stress due to torsion – Polar moment of inertia of a hollow/solid circular section –Torsion formula – Tapering and composite shafts – Strain energy due to torsion stored in a shaft – Transmission of power through shaft/pulley systems.

Elastic Buckling of struts

Concept of Elastic stability, Euler Buckling loads for struts with different end conditions, eccentrically loaded struts, struts with initial curvature, stuts with lateral loads, struts with eccentric axial loads.

06 hrs

Atomic Structure and Molecular Structure

Structure of Atom: Electron, Proton, Neutron, Isotopes.

Electronic Structure of Elements: Bohr theory, quantum numbers, energy levels, excitation, ionisation, periodic table.

Interatomic Bonding: Ionic, covalent, metallic, ban der waals, and hydrogen bonds. Directionality and polarity of bonds, Relationship between type of bond and basic physical and mechanical properties of materials.

Crystal Structure

Crystallography Crystal systems, unit cell, density, packing factor, Miller indices.

Crystal Structure Analysis: Production of X-rays, X-ray diffraction, Bragg's Law.

Crystal Defects:	Point, line, interfacial, and bulk defects.

10 hrs

Equilibrium Phase diagrams

Alloy Systems	Solid solutions, intermetallic compounds.
Phase Equilibria	Single component systems, multi- component systems, phase rule, interpretation of phase diagrams, equilibrium and non-equilibrium microstructures.

06 hrs

Introduction to Properties of Materials

Mechanical Properties of Materials	Elastic and Plastic deformation, stress-strain characteristics, modulus of elasticity, yield stress, tensile strength, ductility.
Mechanical Testing Methods	Tensile, impact, compression, and hardness tests.
Physical Properties of Materials	Ductile to brittle transition temperature fatigue and Creep.
Thermal Properties	Thermal conductivity, thermal expansion, melting point. Electrical and Electronic Characteristics: Ionization, thermionic emission, photo-electric emission, electrical conductivity, behaviour of conductors, semi – conductors, and insulators.
Radioactivity	Nuclear materials, Kinetics of radioactivity, detection and measurement of radioactivity, fission and fusion.
Physical properties of Materials	Thermal properties; Thermal Conductivity, thermal expansion, melting point, Electrical and Electronic Characteristics: Ionisation, themionic emission ……

12 hrs

Laboratory Experiments

1. Tensile Testing of Metals
2. Impact Testing of Steel (at different temperatures)
3. Hardness Testing
4. Microstructure Examination

RECOMMENDED BOOKS

1. Strength of Materials & Structures, J. Case, L. Chilver, C.T.F. Ross
2. Strength of Materials, G.A. Ryder (Publisher – William Clowes & Sons Ltd.)
3. Strength of Materials, Sadhu Singhe (Indian Book, Khanna Publishers)
4. The Elements of Materials Science, L.H. Van Vlack, Addison – Wesley
5. Materials Science, J.C. Anderson and K.D. Leaver, Van Nostrand Reinhold, New York.

6. Introduction to Engineering Materials, V. B. John, Macmillan
7. Properties of Engineering Materials, R.A. Higgins, Hodder and Stoughton – London.

104. ELECTROTECHNIQUES

Lectures = 80 hrs

SI System of Units

02 Hours

Electric charge : description of the Electric field of charges at rest;
Colombo's law, Gauss's law.
Permittivity, Field Energy, dielectrics, insulation.
Determination of capacitance.

06 hrs

Effects of Electric and Magnetic Fields on charged particles
Election beam deflection.

04 hrs

Elements of plane radiation field in free space

03 hrs

Conduction current as the movement of charge Electric and Magnetic fields of charges in motion.
Ampere's law, left hand rule, Biot-Savart law.

04 hrs

Conductivity, conduction loss, continuity resistance, ohm's law, Kirchoff's laws Ideal energy dissipating and energy storage parameters. Energy sources and loads; constant current and constant voltage sources.

03 hrs

Induced emfs – Faraday's and Lenz's laws Electromagnetic systems.

02 hrs

Magnetic field of simple linear current configurations.
Permeability, field energy, inductance. Simple magnetic circuits,

05 hrs

Transient responses of ideal network elements to step, ramp and sine stimuli. Mechanical and thermal analogues.

04 hrs

Cyclic repetitions; qualitative analysis of periodic waveforms as harmonic sums.

03 hrs

A.C. waveforms – average, rms values. Steady state single phase a.c. networks.

Resistance, reactance, conductance, susceptance impedance and admittance.
Series and parallel circuits. Active and reactive power. Power factor.

06 hrs

Network theorems – superposition, equivalent voltage, current sources, etc.
Networks with mutual inductance: coefficient of coupling. Transfer functions of simple RC and LC two-ports.

06 hrs

Resonant circuits, Q-value, bandwidth, selectivity

02 hrs

Logic Systems – combinational systems using or, AND, NOR and NAND gates. Truth tables and Karnaugh maps in the design of simple systems.

04 hrs

Electricity Distribution practices in Sri Lanka. Basics of electricity distribution, including system earthing. Basic wiring circuits in households and in industry.

04 hrs

Basic feedback principles, effects of closed loop systems.

04 hrs

Basic principles of balanced three-phase systems. Power factor improvement; load addition.

06 hrs.

Operation principles of simple instruments used for measuring voltage, current and power.

04 hrs

The ideal transformer
Deviations from the ideal; Analysis of simple single phase transformers under steady loads.

04 hrs

The ideal rotating machine
Conditions for force and torque production.

04 hrs

The laboratory classes in ELECTROTECHNIQUES should consist of five experiments taken from the following:-

1. Insulation and Continuity Testing, and Measurement of earth resistance, earth loop impedance.
2. Study of simple ac circuits
   (including series and parallel circuits comprising R,L and C elements)
3. A study of non-linear devices
   (to include non-linear resistances such as tungsten filament lamps, diodes etc)
4. Measurement of power and energy
   (use of the wattmeter and /or energy meter)
5. Current ratings of fuses and MCBs.

6. Use of bridges for measurement
   (experiment to consist of the use of one bridge circuit, such as Kelvin' Double bridge, Hay's bridge, etc.)
7. Calibration of a meter
   (Calibration of a moving coil meter, moving iron meter or an energy meter)

RECOMMENDED BOOKS

Advanced Electrical Engineering by H Cotton
(Wheeler Publishers, India)
(alternately – ELBS Edition)

or

Electrical Technology by H Cotton 7th Edition (MKS Units)

Or

Advanced Electrical Engineering by Morton

Suggested supplementary texts –

1. Electromagnetism for Engineers by Hammond
2. Electrical Technology by Edward Hughes
   7th Edition ELBS Longmans
3. Basic Electrical Engineering Science by McKenzie Smith and Hosie, ELBS
4. Networks and Systems by D R Choudhury
   Wiley Eastern.

105. THERMODYNAMICS

Lectures = 80 hours

Fundamental concepts

Units and dimensions. Definition of thermodynamic terms such as properties, process, path cycle process, state etc. Boundarles of a system and the interaction between the system and its surroundings.

04 hours

First Law of thermodynamics

Definition of work; calculation of work involved in reversible processes. Heat and work as interactions. Application of First Law of thermodynamic systems. Internal Energy and Enthalpy. Energy equation applied to non – flow processes. Kinetic Energy and Potential Energy. Energy equation applied to flow process. Introduction to simple flow and non – flow process.

12 hrs

Second Law of thermodynamics

Second Law and its corollaries. Reversible and irreversible processes. The efficiency of reversible heat engines. Thermodynamic scale of temperature. Entropy as a property and its relation with other properties. The Clausius Inequality. Isentropic efficiency.

10 hrs

Properties of ideal gases and vapours

Three phases of matter; solid, liquid and vapour. Equilibrium between phases, phase changes, triple and critical points. Tabular and graphical properties of real gases.

10 hrs

Flow and non – flow processes

Flow and non – flow processes undergone by ideal gases and vapours. Equation of state, specific gas constant. Universal gas constant. Relations of specific heats. Relations between entropy changes and changes in other thermodynamic properties.

10 hrs

Vapour power cycles

Carnot cycle for steam. Rankine cycle with and without superheat. Representation of cycles on P V, T – S and H – S diagrams. Thermal efficiency, work ratio and power output. Effect of reheating of steam and regenerative feed heating. Back pressure and pass out turbine plants.

14 hrs

Gas power cycles

Carnot cycle for ideal gas. Otto cycle and Diesel cycle. Thremal efficiency and power output. Correlation with actual four stroke cycle. Cycle efficiency and mean effective pressure as criteria of performance. Practical working of reciprocating internal combustion engines.

12 hrs

Refrigeration

Principle of Vapour compression refrigeration. Properties of refrigerants, representation of vapour compression refrigeration cycle on T – S and P – H charts. Refrigeration effect. Coefficient of performance.

08 hrs.

LABORATORY EXPERIMENTS

i. Compulsory practicals

1. Redwood viscometer
2. Flash point
3. Thomson's calorimeter
4. Boy's Calorimeter

ii, **Optional practicals**

1. Calibration of indicator spring
2. Calibration of pressure gauge
3. Valve timing
4. Marcet's boiler

It is recommended to perform at least five (05) practicals. IESL may select practicals from the optional list.

RECOMMENDED TEXTS

1. Engineering Thermodynamics – Work and Heat transfer
   - by G F C Rogers & Y R Mayhew

2. Applied Thermodynamics – for Engineering Technologists
   - by T D Eastop & A McConkey

3. Thermal Environmental Engineering
   - by James L Threlkeld

4. Basic Engineering Thermodynamics in SI units
   - by Rayner Joel

106 APPLIED MECHANICS

Lectures = 80 hours

FLUID MECHANICS

General Properties of Fluids

Differences between liquids and gasses, ideal and real fluids; Density – Specific Weight – Specific Volume – Pressure Exerted by a fluid – Bulk Modulus – Viscosity – Surface Tension – Units of Measurement.

02 hrs.

Fluids at Rest

Thrusts on vertical and inclined plane immersed surfaces and on curved immersed surfacws – Thrusts on immersed bodies – Centre of Pressure – Lock Gates – Thrusts on Dams.

04 hrs.

Fluids in Equilibrium

Measurement of Pressure – Different types of Manometers and Pressure Gauges – Buoyancy – Centre of Buoyancy – Stability of Submerged and Floating Bodies – Meta Centre Experimental and Analytical determination of Metacentric Height – Floating Bodies containing water – Anchored Floating Bodies – Oscillation of Floating Bodies – Pitching and Rolling – Equilibrium of Moving Fluids.

06 hrs

Dynamics of Fluids

The Continuity Equation – The Euler Equation – The Navier-Stokes Equation – The Velocity Potential Function – the Stream function – Circulation – Vorticity – The Source – The Sink, The Doublet – Flow Nets – Separation – Stagnation Point – Basic Flow Patterns: Rectilinear Flow. Flow from a Line Source,

Flow to a Line Sink – Combination of Basic Flow Patterns: Uniform Rectilinear Flow and Line Source; Source and Sink of numerically equal strength, Source and Sink of numerically equal strength combined with Uniform Rectilinear Flow.

12 hrs

Principles of Fluid Motion

Differences between Uniform and Non-Uniform Flow, Steady and unsteady Flow – Stream Line – Stream Tube – Pressure Head, Velocity Head and Total head – Bernoulli's Equation – Continuity Equation in one, two and three dimensions – Reynold's Number – Transition from Laminar to Turbulent Flow in pipes – Critical Velocity and its determination – Frictional Losses in pipes (Darcy Formula) – Minor Losses in pipes – Simple pipeline problems with reservoir, pipeline, pump combinations with pipes in series and in parallel – Pitot Tube Venturimeter – Orifice (Including large orifices drawned orifices) – Times of emptying rectangular and hemispherical tanks through an orifice – Sharp Crested Weirs, Francis Formula, Bazin's Formula, velocity of Approach, Time of emptying a reservoir with a sharp crested rectangular weir – Notches – Time of emptying a tank through a pipe – Flow between two tanks – Momentum Equation – Force caused by the impact of a jet – Force at a Nozzle and the reaction of a jet – Force on a solid body in a flowing Fluid – Variation of Energy across Stream Lines – Free and Forced Vortices.

16 hrs

MECHANICS

Kinematics

Kinematics of a particle and a rigid body in plane motion. Position. Velocity and acceleration of a points on a rigid body in plane motion. Relative motion, angular velocity, angular acceleration and coriolis law. Velocity diagrams and acceleration diagrams of mechanisms.

8 hrs

Dynamics

Dynamics of a particle and a rigid body in plane motion. Newton's laws of motion. D'Alembert's principle. Work performed on a mechanical system. Power and efficiency. Kinetic energy, potential energy, work-energy relations for a rigid body. Law of conservation of energy.

The impulse – momentum relation for a particle and a system of particles. The moment of momentum of a system. Torque and work done by a torque.

06 hrs

Turning Moment Diagram and Flywheel

Engine torque, load torque and accelerating torque in a simple drive. Cyclic fluctuation of speed. Work done and work absorbed per cycle. Mean speed, coefficient fluctuation of speed and energy. Design of flywheel.

06 hrs

Balancing of Rotors

Static and dynamic balancing of rigid rotors. Resolution method and force and couple polygon method.

06 hrs

Friction

Laws of friction between unlubricated surfaces. Friction formulae for square and V-threads. Plate clutches, cone clutches and centrifugal clutches under uniform pressure and uniform wear conditions.

06 hrs

Vibrations

Free vibration of one degree of freedom systems without damping and systems with viscous damping. Analytical solutions and phase-plane diagrams.

Forced vibration of viscous damped one degree of freedom systems.

08 hrs

LABORATORY EXPERIMENTS

List of suggested experiments

Section I

1. Experimental determination of the Hydrostatic Thrust on Immersed surfaces using the Centre of Pressure apparatus.

   03 hrs

2. Measurement of Frictional Loss in a pipe for Reynold's Numbers in the Laminar and Turbulent ranges

   03 hrs

3. Measurement of Discharge in a pipe using Veturimeter and Orifice meter

   03 hrs

4. Measurement of Discharge using Notches and Weirs

   03 hrs

5. Determination of Cv, Cc, and Cd for orifices

   03 hrs

Section II

1. Static and Dynamic Balancing

   03 hrs

2. Hook's Joint

   03 hrs

3. Equivalent Moment of Inertia

   03 hrs

4. Velocity Diagrams

   03 hrs

RECOMMENDED BOOKS

1. fluid Mechanics, B.S. Massey, Van Nostrand Reinhold Co.
2. Applied Hydrodynamics, H.R. Vallentine, Butterworths.
3. Fluid Mechanics, J.F Douglas, J.M. Gasiorek and J.A. Swaffield, ELBS/Pitman
4. Engineering Fluid Mechanics, J.A. Fox, Macmillan
5. Solution of Problems in Fluid Mechanics parts I & II, J.F. Douglas, Pitman
6. Hydraulics and Fluid Mechanics, Lewitt E.H., ELBS/Pitman
7. Applied Mechanics
   J Hannah & M J Miller (Longmans)
8. Mechanics of Machines – Advanced Theory and Examples
   J Hannah & R C Stephens (Edward Arnold Publishers Ltd.)
9. Applied Mechanics and Strength of Materials
   R S Khurmi
10. A Text Book of Applied Mechanics
    R S Khurmi (S Chand & Co. Ltd., India)

11. Theory of Machines
    R S Khurmi & Gupta

12. Theory of Machines
    P L Ballaney (Khanna Publishers, India)

13. Mechanical Technology
    D H Bacon & R C Stephens (Butterworth – Heinemann Ltd., U.K.)