THE INSTITUTION OF ENGINEERS, SRI LANKA

IESL ENGINEERING COURSE PARTS I, II & III

SYLLABI

120/15,
WIJERAMA MAWATHA,
COLOMBO 7.

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.)

CURRICULA FOR THE IESL COURSES

SYLLABI

PART II,

List of Subjects

Part II

Civil Engineering Stream

6 Subjects, all compulsory

	Number of Hours	
	Lectures	**Practicals**
201. Mathematics	80	
202. Structural Analysis	80	6
203. Surveying	80	42
204. Hydraulics	80	6
205. Engineering Geology and Soil Mechanics	80	18
206. Structural Design – Reinforced Concrete	80	18

Mechanical Engineering Stream

6 Subjects, all compulsory

	Number of Hours	
	Lectures	Practicals
201. Mathematics	80	
212. Applied Thermodynamics and Fluid Mechanics	80	24
213. Mechanics of Machines	80	12
214. Strength of Materials	80	18
215. Production Technology	80	18
216. Materials Engineering	80	18

Electrical Engineering Stream

6 Subjects, all compulsory

	Number of Hours	
	Lectures	Practicals
201. Mathematics	80	
207. Electromagnetic Fields and Networks	80	
208. Electrical Machines I	80	24
209. Power Systems I	80	18
210. Electronics	80	24
212. Applied Thermodynamics & Fluid Mechanics	80	24

Electronics, Communications & Computer Engineering Stream

6 Subjects, all compulsory

201. Mathematics
207. Electromagnetic Fields and Networks
208. Electrical Machines I
209. Power Systems I
210. Electronics
211. Communications

PART TWO

List of Subjects

201	***Mathematics***
202	***Structural Analysis***
203	***Surveying***
204	***Hydraulics***
205	***Engineering Geology and Soil Mechanics***
206	***Structural Design: Reinforced Concrete***
207	***Electromagnetic Fields and Networks***
208	***Electrical Machines I***
209	***Power Systems I***
210	***Electronics***
211	***Communications***
212	***Applied Thermodynamics and Fluid Mechanics***
213	***Mechanics of Machines***
214	***Strength of Materials***
215	***Production Technology***
216	***Materials Engineering***

201 **MATHEMATIC**S

Lectures = 80 Hours

10 hrs

Calculus: Brief introduction to improper integral, differentiation of integral. Function of two or three variables, multiple integral, Taylor series applications. Constrained maxima and minima, Lagrange multipliers

10 hrs

Laplace transform of elementary functions and some basic theorems on Laplace transform. Application of Laplace Transform to solution of differential equation and systems, transfer function, convolution theorem, concepts of stability and controllability.

08 hrs

Ordinary linear differential equations with variable coefficients, solution in series, special function (eg. Bessel, Legendre) – Singular points, Existence and uniqueness of the solution (elementary discussions without proof).

15 hrs

Vector Calculus : Vector differentiation and differential operators, space curves and line integral, surfaces and surface integral. Diverqence theorem, Stokes' theorem, Green's theorem in plane. Some basic applications.

20 hrs

Linear Algebra: Brief treatment of vectors in higher dimension (linearly independent vectors, orthogonal and normal vectors) – Schemes for solution of simultaneous linear equations (Gauss elimination scheme for tridiagonal matrices, triangular decomposition). Partitioned matrices. Eigen value problem (Algebraic determination of eigen values, properties of eigen values, eigen values of symmetric matrix, similar matrices, quadratic form and their reduction). Some basic applications to boundary value problems.

08 hrs

Fourier Series Approximation Fourier coefficients, Dirichlet's condition, odd and even function, half range series, Trigonometric approximation to discrete data.
07 hrs

Basic Probability and Statistics: Classificatin of data, continuous and discrete variate. Determination of mode, median, mean, variance and standard deviation. Elementary probability, addition and multiplication of probabilities, binomial, poisson and normal distribution. Simple application.

RECOMMENDED BOOKS

1. Advanced mathematics for Engineers and Scientists by G S Sharma, K L Ahuja and IJS Sarma, CBS Publishers New Delhi. Vol. I & II (Multiple Copies)
2. Mathematics for Engineers and Scientist by Alan Jeffery
3. Schaum's Outline Series books on
   - Matrices
   - Linear Algebra
   - Vector Analysuis
   - Calculus
   - Advanced Calculus
   - Differential Equations
   - Numerical Analysis
4. Advabced Engineering Mathematics by A C Bajpai, L R Mustoe, D Walker, (Multiple Copies)

202 STRUCTURAL ANALYSIS

Lecture = 80 hours

Basic Concepts in Structural Analysis 02 hrs

Force (external, internal), displacement, support types, equations of static equilibrium, statical determinacy.
04 hrs

Analysis of Statically Determinate Structures 04 hrs

Analysis of plane trusses and space trusses, determination of support reactions and member forces using external and internal equilibrium, Method of joint resolution, Method of Sections, Method of tension coefficients

Influence lines and moving loads

06 hrs

Influence lines for reactions, bending moments, shear forces, axial forces in simple beams and trusses, applications of influence lines, moving point loads, moving udls shorter and longer than the span, counterbracing.

Three Moments Theorem

06 hrs

Three moments equation, applications in continuous beams.

Energy Theorems

12 hrs

Strain energy stored in elements due to axial, bending, torsional & shear effects, Castigliano's theorems, principle of virtual work, Engressor's theorem, lack of fit and temperature effects in structures, analysis of statically determinate and indeterminate structures using energy theorems.

Slope Deflection Equations

06 hrs

Derivation of slope deflection equation, applications in beams and plane frame, moments due to support settlements, support rotations and sway.

Moment Distribution

12 hrs

Fixed end moments, Stiffness of elements, distribution factors and carry-over factors in elements, moment distribution procedures, symmetry and anti-symmetry, sway analysis, correction factors, applications in beams, single and multi-storey frames.

Reciprocal Theorems 04 hrs

Clark-Maxwell reciprocal theorem, Betti's theorem, Muller-Breaslau principle, application in simple structures and model analysis.

Arches 08 hrs

Significance of arch profile, theoretical and actual arch profiles, three pinned, two pinned and tied arches, bending moment, axial thrust and radial shear in arches, influence lines, effects of temperature changes.

Suspension Bridges

06 hrs

Unstiffened cable bridges, bridges with three-pin stiffening girder.

Theories of Elastic Failure

06 hours

Maximum principal stress theory, maximum shear stress theory, maximum principal strain theory, maximum strain energy theory, ductile and brittle material.

Stress Analysis

08 hours

Stress in Cartesian and polar co-ordinates, stress functions (Airy stress function), applications of stress functions, experimental stress analysis, strain gauges, strain rosettes.

LABORATORY EXPERIMENTS

06 hours

1. Tensile test
2. Elasticity of timber

RECOMMENDED BOOKS

Analysis of Structures (Vol. I), VN Vazirani, MM Ratwani, Khana Publishers, New Delhi

Analysis of Structures (Vol. II),VN Vazirani, MM Ratwani, Khanna Pubishers, New Delhi

Theory of Structures, S Timoshenko, DH Young, McGraw Hill, New York

Structural Analysis, Jack C McCormac, Harper & Row, New York

Indeterminate Structures, JS Kinney

202 SURVEYING

Lectures = 80 Hours

Overview of basic Surveying Techniques

02 hours

Basic principles of survey methods. Overview of Chain Surveying, Compass Traversing and Plane Table Surveying.

Levelling

10 hrs

Basic optical and mechanical principles of Dumpy and Tilting levels. Temporary and permanent adjustments of dumpy and tilting levels. Principles and practices in leveling. Booking systems and calculation of reduced levels. Errors in leveling. Sensitivity of bubble tube. Effect of Earth's curvature and atmospheric refraction. Standards of accuracy. Trigonometric Leveling, Reciprocal Leveling and Precise Leveling.

Theodolite and Theodolite Traversing

12 hours

Optional and mechanical properties of vernier theodolites and modern precise theodolites. Operating and adjusting the theodolite. Measurement of horizontal and vertical angles. Booking systems and computations. Errors due to malconstruction and their effects. Errors due to non-adjustment of permanent errors. Theodolite traversing and traverse computations. Plotting of a traverse. Adjustments for closing errors in traverse. Sources of error in theodolite traversing.

Tacheometry

06 hours

Instruments used. Stadia tacheometry. Anallactic lens. Subtense tacheometry. Errors in tacheometry. Accuracy of measurements.

Contours and Contouring

04 hours

Definitions, characteristics and uses of contours. Methods of contouring. Determination of spot heights. Grades and slopes.

Areas, Volumes and mass-Haul Diagrams

08 hours

Determination of area from the plans; area using instrumental and graphical methods, field notes, latitude and double longitude method, and departure and latitude method. Trapezoidal and Simpson's Rules for areas. Area of cross-sections. End-area formula and prismoidal formula for volumes. Calculation of volume from sections, spot-heights and contour plans. Mass-Haul Diagram (MHD), bulking and shrinkage, construction of MHD, properties of MHD, balancing procedures.

Air Surveys

10 hours

Aerial photography. Characteristics of a photograph. Ground control points. Parallax. Stereoscopy. Ground height form parallax readings. Parallax formula. Mosaics and photomaps. Distortion of images on aerial photographs. Introduction to the use of stereoplotters.

12 hours

Theory of Errors

12 hrs

Errors in Surveying and their sources. Theory of Probability. Theory of Least Squares. Application of Theory of Probability and Theory of Least Squares to Surveying. Solution of binomial equations. Weighting of errors.

Curve Ranging

12 hrs

Horizontal circular curves and their application in Highway and Railway construction. Simple, compound and reverse curve. Setting-out of horizontal circular curves. Transition curves; cubic, spiral and cubic spiral curves. Principles of transition. Design and setting out of transition curves. Vertical curves; sag

and summit curves. Approximations used in vertical curve computations. Design factors and radius of the curve.

Surveying for Building Construction

02 hours

Setting out buildings and other structures

Introduction to Elector-Magnetic Distance Measurement

02 hours

Basic principles of EDM and instrument types (using long radio waves, micro waves, visible light and infra-red radiation)

RECOMMENDED BOOKS

1. Surveying – by A bannister and S Raymond. Publisher: Pitman Publishing Ltd.
2. Elementary Surveying – by S K Mahajan (Indian book). Publisher: Dhanpat Rai & Sons
3. Advanced Surveying – by S K Mahajan (Indian book). Publisher: Dhanpat Rai & Sons

LABORATORY EXPERIMENTS

42 hours

1. Levelling (Introduction of Instruments, LS & CS work, plotting)

15 hours

3. Theodolite Traverse (Instroduction of Instruments, traversing, plotting)

21 hours

4. Tacheometry (Spot levels, contouring)

06 hours

203 HYDRAULICS

Lectures = 80 HOURS

Boundary Layers

08 hrs

Viscosity of Fluids – Definition of boundary Layer – Displacement Thickness & Momentum Thickness – Distribution of Shear Stress and Velocity and Computation of Drag Force in Laminar and Turbulent Boundary Layers – Drag Coefficient – Dynamic Pressure – Form Drag and Skin Friction Drag – Wakes – Streamlining of bodies - Lift and Drag of Aerofoils.

Pipe Systems and Networks

08 hrs

Equations for Frictional Loss in Pipes – Darcy Formula – Manning's Formula – Hazen William's Formula – Relationship between the Coefficients of different formulae – variation of Friction Factor with Reynold's Number and Relative Roughness (Mody Diagram) – Pipe Networks - Analysis of Pipe Networks using Iterative Methods (Hardy Cross Method).

Transient Flow in Pipes

10 hours

Water Hammer – Incompressible Water Column Theory – Elastic Theory of Water Hammer for a simple pipe – Sudden Closure – Strain Energy Water Hammer Theory – Fundamental Differential Equation of Water Hammer – Velocity of Propagation – End Conditions – Reflection at a Reservoir – Reflection at a Dead-end – non Instantaneous Closure and opening. Surge Tanks – Purpose of Surge Tanks – Types of Surge Tanks – effect of Friction – Theory of Mass
Oscillation – Simple Finite – Difference methods of solution – Solution of Surge Tank problems using Scale Models.

Dimensional and Hydraulic Model Analysis

10 hours

Dimensionless Numbers – Buckingham's Theorem – Hydraulic Similarity – Hydraulic Models of different types of Structures – Distorted Models of Tidal Estuaries.

Hydraulic Machinery

16 hours

General Introduction – Types of Pumps and Turbines – Total Head of Pumps and Turbines
Reciprocating pumps – Components and Mechanism – SHM of Piston – Single and Double acting Pumps – Slip – Inertia Pressure – Friction in Suction and Delivery Pipes – Air Vessels – Work saved by Air Vessels – Indicator Diagram – Limiting Pressures in Suction and Delivery Pipes – Cavitation – Practical Applications and Limitations of Reciprocating Pumps.
Certifugal Pumps : General Equation for Head Generated – Velocity Triangles – Efficiencies – Specific Speed – Performance at Constant and Variable Speed – Guide Vanes – Volute Casing – Priming of Centrifugal Pumps – Self Priming Pumps – Deep Well Pumps – Installation of Centrifugal Pumps.
Impulse and Reaction Turbines : General Equation for Power Generated – Velocity Triangles – Pelton Turbine – Velocity ratio and speed regulation in Pelton Turbines – Francis Turbines – Specific Speed – Efficiencies – Characteristic Curves – Guide Vanes – Draft Tubes – Selection of Turbines – Introduction to Hydro Power installations in Sri Lanka.

Uniform Flow in Open Channels

04 hours

Equations for Uniform Flow – Chezy and Manning's Equations – Normal Depth – Economic Section.

Water Quality

24 hours

Characteristics of Water Quality : Introduction to Water Quality Concepts – The need for Water Quality Studies and Water Quality Standards – Physical, Chemical and biological Characteristics of Water -–Water related Diseases.
Treatment of Water Supplies : Introduction to Water Treatment Processes – Screening – aeration – Plain Sedimentation – Coagulation – Flocculation & Sedimentation – Filtration – Disinfection.

Waste Water Treatment : Introduction to Waste Water Treatment Process – Primary, Secondary, and Tertiary Treatment Methods.

Water and Waste Water Systems : Water Supply Systems – Collection, Treatment, Transmission and Distribution Works – Sources of Water Supply- Population Growth – Water Demand and Variations in

Flow – problems dealing with Reservoir Capacities and Pumping Rates using Mass Diagrams – Application of Pump and System Characteristic Curves to Water Supply Problems.
Waste Water Systems – Collection, treatment and Outflow of Disposal Works of Waster Water Collection Systems – Estimation of the Quantities Pipe Diameters using Nomographs and the application of Partial Flow Diagrams – Design Periods for Water Supply and Waste Water Structures and the factors affecting them.

Water Pollution and its Control : Types and Sources of Pollution – Outline of the Overall effects of Water Pollution and Control Measures.

RECOMMENDED BOOKS

1. Fluid Mechanics for Civil Engineers, N.B. Webber, E&F.N. Spon Ltd.
2. A Textbook of Fluid Mechanics, J.R.D. Francis, Edward Arnold (Publishers) Ltd.
3. Analysis of Surge, John Pickford, Macmillan
4. Dimensional Analysis and Hydraulic Model Testing, H M Ragunath, Asia Publishing House, London.
5. Solution of Problems in Fluid Mechanics, Parts 1 & 2, J F Douglas, Pitman
6. Water and Waste Water Engineering, G M Fair, J C Geyer, and D A Okum, John Wiley & Sons

LABORATORY EXPERIMENTS

1. Determination of Frictional Coefficient for Commercial Pipes.
2. Surge Tank experiment to compare Theoretical and Actual variation of amplitude with time for different discharges.
3. Testing of Reciprocating and Centrifugal Pumps.
4. Testing of Turbines.
5. Determination of Bed Roughness Coefficients in Channels using Uniform Flow.
6. Determination of the Quality of Water and Waste Water.

205 ENGINEERING GEOLOGY AND SOIL MECHANICS

Lectures = 80 Hours

Engineering Geology

02 hrs

Earth's place in the space. History of the earth

02 hrs

Structure of the Earth. Geological processes of the Earth's crust

06 hrs

06 hrs

Process of weathering, erosion transportation and deposition. Nature distribution and engineering characteristics of sediments deposited in different environments, deltaic, desert, flurial, glacial, periglacial, residual soils.

06 hrs

Deformational features of the earths crust and deformational features of rocks. (foliation, folds, faults, lineations and joints). Intraformational shears. Nature and origin in relation to stress fields.
Formation and classification of sediments and sedimentary rocks

04 hrs

Metamorphism, metamorphic grades and classification of metamorphic rocks.

04 hours

Igneous activity, formation of igneous rocks and classification of igneous rocks

04 hours

Theory of plate tectonics and associated activities

02 hours

Geological time scale. Principles of stratigraphy

02 hours

04 hours

Geological and geotechnical maps, their interpretation and mapping. Interpretation of aerial photographs. Measurement of planer structures in the field. Rose diagrams and stereographic nets.

06 hours

The design and execution of site investigations; for dam sites and reservoirs, underground tunnels, building sites and road projects. Drilling, coring trial pits and sampling. Logging bore holes.

04 hours

Geophysical investigation methods mainly used for site investigations. Seismic prospecting methods and electrical prospecting methods.

06 hours

Principles of hydrogeology. Rock and soil permeability. Groundwater regimes, springs, aquifers and aquicludes. The engineering significance of groundwater conditions. Influence of rocks and sediments on groundwater. Groundwater pollution.

04 hours

Construction materials. Suitability of rock types and soils etc. for construction industry. Locating rock quarries and borrow pits.

Introduction to Sri Lankan geology.

02 hours

SOIL MECHANICS

1. Basic soil properties
   Mass, Volume, void ratio, moisture content definitions. Specific gravity. Density relationships.

   Particle size distribution (Sieve Analysis and Hydrometer Analysis)

   Atterberg Limits

   06 hours

2. Classification of Soils

   03 hours

   Classification of Soils for engineering purposes, purpose of Classification, different systems,

Unified Classification System

3. Compaction of Soils

04 hours

Proctor compaction test, AASHO test, air voids ratio, Compaction in the field, Compaction Control, Field testing of density, Principles of soil stabilization.

4. Permeability of Soils

08 hours

Darcy's law, Hydraulic gradient, Coefficient of permeability, Laboratory and field measurement of permeability, Steady seepage.

LABORATORY EXPERIMENTS

Soil Mechanics Laboratory Classes – 5 Classes – 15 Hrs.

Particle Size Distribution
Atterberg Limits
Compaction Properties
Insitu Density of Soils
Determination of Coefficient of Permeability in the Laboratory.

Engineering Geology – Geology Map 10 Classes – 30 hrs.

Map 1 - Drawing strike lines for foliations and calculation of true dip.

Map 2 - Drawing geological cross sections perpendicular and parallel to the strike direction of the foliation.

Map 3 - Completing a geological map with given geological data.

Map 4 - Use of underground geology (3 bore holes) to prepare a surface geological map

Map 5 - Work on a map with repeated foldings.

Map 6 - Work on a map with a fault.

Map 7 - Work on map with a fault and unconformity

Map 8 - Preparing a geological map using given data

Map 9 - do

Map 10 - do

206. STRUCTURAL DESIGN: REINFORCED CONCRETE

Lectures = 80 hours

Introduction to Design

06 hours

Design - difference between analysis and design; steps involved in structural design (layout, load evaluation, idealisation, analysis, section design); partial safety factors; limit state deign; ultimate and serviceability states; code of practice, i.e. BS 8110.

Materials - characteristic and design strengths; idealised stress-strain curves for concrete and steel; partial safety factors for materials.

Loads - characteristic and design loads; types of loads (dead, imposed, wind); partial safety factors for loads.

Ultimate Limit State of Flexure

12 hours

Fundamentals of reinforced concrete behaviour – concrete stress blocks; stress in steel and conditions for yielding; under-reinforced and over-reinforced sections; analysis of a section by strain compatibility.

Design of rectangular beams – choice of section; minimum depth for under-reinforced section; calculation of reinforcement for singly reinforced and doubly reinforced sections using design formulae; use of design charts; minimum and maximum percentages of reinforcement; effective span slenderness limits.

Design of flanged beams – locations of flanged beam action; effective flange width; design of flanged beams using design formulae

Deign for Shear

08 hours

Types of shear failure – diagonal tension, shear span

Shear resistance of concrete – uncracked concrete, aggregate interlock and dowel action; dependence of shear resistance on concrete grade, percentage of steel and depth of section; enhanced shear resistance near supports.

Design of shear reinforcement – truss analogy; vertical link reinforcement; designed and nominal reinforcement; detailing rules; introduction to bent-up bars.

Serviceability Limit States

04 hours

Deflection – use of span/depth ratios

Crack width – use of maximum spacing rules; also minimum spacing rules to avoid reinforcement congestion.

Considerations affecting Detailing

06 hours

Cover – based on exposure conditions and grade; adaptation for Sri Lanka conditions; based on fire resistance requirements

Achorage bond stress – dependence on stress state, concrete grade and bar type; hooks and bends; rules for lapping of bars; rules for curtailing bars; difference between theoretical and practical cut-off points; simplified curtailing rules for beams and slabs.

Slabs

08 hours

General – importance of deflection criterion for slabs; trial span/depth rations; bar spacing rules.

One way slabs – design as shallow beams; conditions for and method of simplified coefficients for analysis of a 1-way slab system.

Two way slabs – moment coefficients for simply supported and restrained slabs; different support conditions; middle strips, edge strips and torsion in restrained slabs; shear coefficients.

Columns

12 hours

Classification and Loading – short vs. slender; braced vs. unbraced; effective height; determination of moments and forces in columns.

Short columns – design equations for column with predominantly axial load; design charts for columns with axial load and moment; biaxial bending; detailing rules for longitudinal and link reinforcement.

Slender Columns - moments due to deflection (in braced and unbraced columns); moments at different points (i.e. ends and mid-heights) of columns; additional moments due to slenderness; use of design charts, including reduction of additional moments

Foundations

06 hours

Types of foundations – e.g. pad, strip, combined, raft, pile

Pad footings – choice of dimensions for carrying axial load and moments; use of service loads for bearing capacity check; ultimate state design for reinforced concrete; design for bending as inverted cantilever slab; detailing and anchorage; vertical line shear; punching shear; choice of footing depth based on shear considerations.

Staircases

06 hours

Choice of dimensions (going, rise, tread, waist); types of staircases (transverse and longitudinal spanning); design as inclined 1-way slab; load evaluation; detailing.

Analysis and Design of Structure

12 hours

Frame analysis for vertical loads – stiffness calculations; sub framing and moment distribution; loading patterns.

Frame analysis for horizontal loads – braced and unbraced frames; load combinations; analysis using hinges at beam and column midpoints.

Redistribution of moments – M-0 curves and plasticity; plastic hinge formation with increasing load; redistribution procedure; constraints on redistribution; rationale for redistribution.

Design for stability – design philosophy for non-catastrophic failure; physical barriers; robust layout; notional horizontal load; key elements; bridging elements; types of ties (international, peripheral, column/wall, vertical); tie forces; arrangement of ties; anchorage of ties.

LABORATORY EXPERIMENTS

18 hours

Design of multi-story framed structure, preferable including the following aspects:-

(a) Partition loads on slabs
(b) Two-way slabs with unequal adjacent edge moments
(c) Analysis of beam for lad patterns
(d) Redistribution of moments in beams
(e) Design of column for various load combinations
(f) Design of pad or combined footing
(g) Proportioning and design of staircase

207 ELECTROMAGNETIC FIELDS AND NETWORKS

1. **Electromagnetic Fields**

1.1 **Electrostatic Fields**

10 hours

Field Equations and boundary conditions, Laplace & Poission's Equation, Applications to simple cases.
Mapping and images methods in solving field problems. Capacitance coefficients

1.2 **Fields produced by currents**

10 hours

Field equations, boundary conditions, analogy to electrostatic fields, magnetic potentials, calculating H&B in fields produced by conductor and coil configurations. Self and mutual Quasi stationary fields, continuity equation.

1.3 **Numerical methods of fields calculation**

06 hours

Formulation of field problem, finite element method, finite difference method. Common field solution packages 2D and 3D models.

1.4 **Electromagnetic waves**

14 hours

Maxwell's equations, Properties of transverse waves

Concepts of wave impedance, Poynting theorem, polarisation, retarded functions.
Penetration of electromagnetic waves into conductors, skin effect
Guided electromagnetic waves (TEM, TE and TM waves)

2. Networks

06 hours

2.1 Techniques of formulation and solution of network equations graph theory, nodal and Mesh formulation Matrix representation and manipulation solution of network equations, solution of Transient equations.

2.2 **Fourier Transform**

04 hours

Non-sinusoidal waveforms, analysis using fourier series

2.3 **Laplace Transform**

06 hours

Solution of network transients using the Laplace transform.

2.4 **State-Space representation**

06 hours

Selection of state variables, transformations, canonical forms, eigen values, solution of State-space equations.

2.5 **The S-plane**

04 hours

The general complex exponential excitation function, Net work functions, Pole-zero patterns, properties of LC, RC and RLC network functions, Energy functions.

2.6 **Synthesis of Passive**

04 hours

Synthesis of LC, RC, and RLC networks, Cauer, Foster Canonical forms and other methods.

2.7 **Filter Design**

10 hours

Classical Filter Design : Two-port network parameters, Image impedance, Matching, Low pass, high pass band pass filters, cascade sections and terminations, Crystal filters.

Modern Filter Design : Butterworth & Tschebycheff approximations, Scattering matix (reflection coefficient), Realisation, frequency transformations.

Active Filter Design : Amplifiers, Gyrators and negative impedance converter techniques, Realisations to active filters, sensitivity.

RECOMMENDED BOOKS

1. CTA Johnk, Engineering Electromagnetic fields and waves, John Wiley & Sons, 1975.
2. Javid & Brown, Field Analysis and Electromagnetics, McGraw-Hill Book Company, Inc.
3. G Doetsch, Guide to the Applications of the Laplace and z-Transforms, New York: Van NostrandReinhold Company, 1971.
4. S Karni, Analysis of Electrical Networks, John Wiley & Sons, 1985.

5. FM Reza & S Seely, Modern Network Analysis, McGraw-Hill Book Company Inc.

208 ELECTRICAL MACHINES I

Lectures = 80 hours

Introduction and Principles

06 hours

Basic electromechanical principles
Primitive linear and rotary machines. Effects of motion: pulsational and motional emfs.

Transformers

10 hours

Revise – Ideal transformer, equivalent circuit.
Three phase transformers: evaluation of equivalent circuit parameters of a power transformer; construction – insulation, Wingings; mechanical forces; cooling; temperature distribution; thermal rating; harmonics; noise; tap-changing.
Auto and instrument transformers
Three phase transformer notations
Parallel operation of transformers.

AC Machines

30 hours

Principle of rotating magnetic field
Basic concepts of synchronous machines and its operational modes.
Electromagnetic interaction in induction motors.
Types of induction motors. Equivalent circuit and parameters of induction motors.
Efficiency of induction motors.
Characteristics and performance of three-phase induction motors. Starting and speed control of induction motors.
Other modes of operation of induction machines.

Special characteristics of single phase induction motors, and its influence on the starting methods.
Two phase servo motor; linear induction motor concepts.

DC Machines

24 hours

Separately excited dc machine. Armature windings; effect of armature reaction and communication process.
Steady state equivalent circuits and characteristics of dc shunt, series and compound machines.
Starting and speed control of different types of dc motors.

General

10 hours

Machine ratings: losses, cooling, thermal conduction and convention; temperature rise; thermal cycles, thermal rating; transient heating.
Reluctance motors and their applications

Classification of electrical machines and selection of industrial drives

LABORATORY EXPERIMENTS

Students have to do 8 Experiments from the followings:

1. D C Machines – OC characteristics, load characteristics for series, shunt and compound wound motors, generators.

2. Induction Motor - Load characteristics, OC and SC test etc.
3. Single phase induction machines.

4. Transformers – OC and SC test, load test, measurement of sequence impedances.

5. Temperature rise test

(The experiments carried out should include each of DC machines, transformers and induction machines)

RECOMMENDED BOOKS

1. Alternating current Machines – M G Say : Longman Scientific & Technical

2. Electrical Machinery – P S Bimbhra : Khanna Publishers, Delhi

209 POWER SYSTEMS I

Lectures = 80 hours

Introduction

12 hours

Conventional and alternative sources of energy; Environmental and ecological consideration; power needs of the world; Load forecasting; Methods of generation of electricity; Large scale generation of electrical power; Thermal, nuclear, hydro, pumped storage, OTEC, solar, wind, wave, their advantages and short comings; power generation in Sri Lanka; Economics of Power generation.

Power Transmission

12 hours

Overhead lines, underground cables, conductor types and insulation materials.

Line parameters: Resistance, inductance, capacitance, bundle conductors, transposition;
Line insulators: Types, voltage distribution, string efficiency.

Transmission line performance

12 hours

Short, medium and long line calculations; ferranti effect; shunt and series compensation; generalised circuits constants; equivalent T and II circuits; Receiving-end sending-end and universal circle diagrams; power limits.

Faults

08 hours

Review of symmetrical components and per-unit system; symmetrical three phase faults; unsymmetrical faults; fault levels.

Switchgear

10 hours

Types of switchgear and fuses; fault clearing and interruption of currents; arc formation; mehtod of quenching; restriking and recovery voltage transients; circuit breaker; various capacities and principle of operation; Indoor and outdoor types; Oil circuit breakers, air circuit breakers, miniature circuit breakers, air blast and sulphur hexafluoride circuit breakers.

Protection

12 hours

Current and potential transformers; Overcurrent relays; Inverse definite minimum time (IDMT), directional, differential protectionl; Pilot wire protection; distance relays; Amplitude and phase angle comparators; Characteristics in the resistance-reactance plane Protection of generators, transformers, busbars and transmission lines.

Power Distribution

14 hours

Feeders and distributors; Radial and ring types; Substation layout; Tariffs and tariff structure in Sri Lanka; Economic of utilisation, power factor improvement; Load curves, load factor, diversity factor, coincidence factor, utilisation factor, plant factor etc.

RECOMMENDED BOOKS

1. Allan J Wood, Bruce F Wollenberg, Power Generation Operation and Control, John Wiley & Sons, New York, USA, 1994

2. Weedy B M Electric Power Systems, John Wiley & Sons, New York, USA, 1983

3. Elgerd O, Electric Energy Systems Theory, McGraw-Hill Book Company, New York.

4. William D Stevenson, Jr. Elements of Power System Analysis, McGraw-Hill Book Company, New York, 1982

LABORATORY EXPERIMENTS

Study of Load and diversity Factors

Familiarization of the definitions. Investigation of load and diversity factors for different loads types with specified diversifications.

Earthing of Electrical Installations

Study of the theoretical concepts of earthing and determination of earth resistance of an electrode at different depths of insertion with the position of potential electrode varied; Measurement of the resistively of earth.

Study of Distribution System

Study of the variation of voltages of uniformly loaded radially and ring connected distribution lines using models and determination of voltage regulation.

Study of Operation of Peterson Coil

Study of the function of arc suppression coil with an earth fault in one of the lines in a three phase system; Determination of the value of inductance which minimises the earth fault current.

Suspension insulator string

Familiarisation of methods of granding high voltage suspension insulator strings; Determination of the voltage distribution along the string and string efficiency with different insulator moderls.

Study of Transmission Systems I

Determination of ABCD parameters and voltage regulation of a balanced three phase transmission line modelled with a single phase equivalent circuit.

Study of Transmission Systems II

Development of sending-end and receiving-end circle diagrams associated with a transmission line using a laboratory model.

Study of overcurrent relays

Familiarisation of the operation of the inverse over current relay; Study of pick up value, time adjustment with different plug settings and time multiplier settings.

210 ELECTRONICS

Lectures = 80 hours

Semiconductor theory 02 hrs

Properties of semiconductors, effects of doping, n type and p type semiconductors.

Diodes 08 hrs

Behaviour of pn junction, diode characteristic curve and current equation, equivalent circuits, zener and Schottky diodes; diode circuits: rectification, demodulation, limiting, clamping and regulation.

Bipolar Junction Transistors 16 hrs

Npn and pnp junction behaviour, typical I-V characteristice, dc and ac load lones, biasing, stabilization of the operating point. Single transister amplifiers using common emitter, common collector and common base configurations, small single low frequency equivalent circuits, calculation of basic amplifier parameters; gain, bandwidth, input and output impedance, decibel notation, multiple transistor configurations, application of BJT as a switch.

Field Effect Transistors 08 hrs

JFETS and MOSFETS, construction and principle of operation, typical I-V characteristics, biasing, simple amplifier configurations, small signal equivalent circuits, applications as a switch.

Operational amplifier 06 hrs

Ideal characteristics, typical specifications, basic amplifier circuits, summer amplifier, integrator, differentiator and comparator circuits.

Feedback 08 hrs

Principle of closed-loop systems, simple analysis of series-fed voltage feedback in amplifiers, effects of negative feedback on gain, bandwidth, distortion, stability, input and output impedances, simple transistor and operational amplifier circuits using negative feedback, effects of positive feedback, simple oscillator circuits.

Combinational logic

12 hrs

Digital signals, basic gates, truth tables, construction of basic gates using resistors, diodes and transistors, common logic families((TTL, CMOS, ECL), design limitation imposed by noise margins, fanout, Boolean algebra, minimization of expressions using AND-OR gates and NAND gates, multiplexes, decoders, comparators, adders; programmable logic devices.

Sequential Logic

12 hrs

Sequential model, latches, RS, JK D and T flip-flops, parallel registers serial registers, asynchronous and synchronous counters, design of simple finite state machines: state diagrams and tables, transition tables, implementation using flip-flops and ROMs.

Introduction to Communication Systems

08 hrs

Radio spectrum, elements of communication systems, amplitude, frequency and phase modulation concepts, demodulation, decibel notation, concepts of bandwidth, signal-to-noise ratio; basic types of pulse modulation.

LABORATORY EXPERIMENTS

1. diode Characteristics and applications
2. Bipola Junction Transistor and its characteristics
3. Field effect Transistors and their characteristics
4. Transistor amplifier
5. Operational amplifier
6. Logic gates
7. Combinational logic circuits
8. Sequential logic circuits

RECOMMENDED BOOKS

1. Bogart, F.G., Electronic Devices and Circuits, Bell & Howell Company, 1986
2. Millmanm, J. & Grabel, A., Microelectronics, McGraw-Hill Book Company, 1987,
3. Tocci, R.J., Digital Systems, Principles and Applications, Prentice hall, 1991.

1. Horowitz, P, & Hill, W., The Art of Electronics, Cambridge University Press, 1989.
2. King R., Integrated Electronic Communications: Modulation and Transmission, Bell & Hoell, 1990.

211. COMMUNICATIONS

Lectures - 80 hours

Signal Analysis

03 hrs

Power signals: periodic waveforms, trigonometric and exponential Fourier series, line spectra, Parseval's power theorem

06 hrs

Energy signals: Fourier transform and transform theorems, continuous spectrum, energy spectral density, Rayleigh's energy theorem

03 hrs

Autocorrelation function, spectral desity functions

04 hrs

System Analysis

Linear systems: impulse response, convolutional integral, transfer function, frequency response, frequency response plots

03 hrs

Signal transmission: distrotionless transmission, group & phase delay, equalization, nonlinear distortions

04 hrs

Filters: Butterworth, Chebyshew, and Bessel filters

09 hrs

Analog Communications

Amplitude modulation: DSB, DSB-SC, SSB and VSB modulations, envelope detection, coherent detection, modulators and demodulators

Phase & Frequency Modulation: Phase modulation, frequency Modulation, PM & FM with tones, wideband & narrowband FM, banwidth occupancy, limiter-discriminator detection, PLL detection, modulators & demodulators, interference effect, deemphasis & preemphasis, companding

02 hrs

Superheterodyne receiver, frequency multiplexing

03 hrs

Pulse Modulation

Sampling theory,: Ideal sampling, aliasing, Nyquist sampling theorem, practical sampling, signal reconstruction techniques

03 hrs

Pulse modulation: PAM, PWM, PPM, modulators & demodulators, cross talk & guard bands, time division multiplexing

04 hrs

Pulse-code modulation: PCM modulation and demodulation, quantization error, QSNR expression, companding, time division multiplexing

03 hrs

Delta modulation: Delta modulator, slope overloading, idling & granular noise, SNR expression, adaptive delta modulation

03 hrs

Digital Transmission Techniques

Baseband data transmission: line coding, bandwidth occupancy, Nyquist signalling rate, intersmbol interference, equalization

06 hrs

Digital carrier modulation: ASK, PSK, DPSK, FSK, modulations, coherent & noncoherent detection, error rate expressions

Introduction to information theory, measure of information, entropy source coding, mutual information, channel capacity

09 hrs

Line Communication

Transmission lines: transmission line equations, reflection coefficient, VSWR, high frequency lines, impedance matching, Smith chart applications.

LABORATORY EXPERIMENTS

1. filters
2. Amplitude modulation
3. Frequency modulation
4. Pulse modulation
5. Pulse-code modulation (delta modulation can also be included)
6. Digital carrier modulation
7. Transmission Line characteristics

RECOMMENDED BOOKS

1. Communication systems, Third Edition - A B Carlson
2. Analog & Digital Communications – Simon Haykin
3. Digital & Analog Communication – Sam Shanmugam
4. Principles of Communication Systems – Taub & Schilling

212. APPLIED THERMODYNAMICS AND FLUID MECHANICS

Lectures = 80 Hours

A. APPLIED THERMODYNAMICS

Positive displacement compressors

Work transfer in reversible single stage reciprocating compressors; volumetric efficiency and isothermal efficiency: multi – stage working with intercooling. Rotary positive displacement compressors.

Steady flow of compressible fluids 12 hrs

Steady one dimensional flow of gases and vapours through nozzles and diffuses; critical pressure ration; effect of friction. Adiabatic flow through long pipes. Concept of stagnation properties at a point in a fluid stream.

Principles of turbo machinery 12 hrs

Mean diameter treatment of kinematics and momentum transfer. Introduction to radial and axial flow machines. Impulse and 50% reaction blading in axial flow turbines; main sources of internal losses; overall, stage and polytropic efficiencies and reheat factor.

Combustion 08 hrs

Combustion of hydrocarbon fuels; volumetric and gravimetric analysis; stoichiometry. Internal Energy of reactions, enthalpy of reactions and of formation. First Law applied to chemical reactions.

B. FLUID MECHANICS

Dimensional analysis 04 hrs

Buckingham – Pi Theorem. Physical significance of dimensionless groups. Geometric and dynamic similarities.

Two dimensional inviscid flow 08 hrs

Definition of irrotational and rotational flow. Circulation, Vorticity. Stream function and velocity potential function for basic combined flow patters (uniform flow, source – sink, doublet, point vortex). Flow around circular cylinder with circulation. Free and forced vortes.

Viscous laminar flow 06 hrs

Newton's Law, Analysis of flow in bounded systems (flow between parallel plates and annuli). Introduction to hydrodynamic lubrication. Characteristics of non – Newtonian fluids.

Turbo machinery 08 hrs

Classification of pumps and turbines. Centrifugal pump head and energy relation, head capacity characteristics. Impulse and reaction turbines. Application of dynamic similarity to turbo machines.

Boundary layer theory 08 hrs

Boundary layer approximations governing 2 – D laminar boundary layer, derivation of Momentum Equation. Similar velocity profiles. Bl.essius solution for flow past flat plates. Skin friction coefficient. Introduction to turbulent boundary layer.

Flow around bluff and streamlined bodies 06 hrs

Introduction to bluff and streamlined bodies. Flow around streamlined bodies. Flow around streamlined bodies and their lift and drag characteristion. Drag characteristics of circular cylinder and sphere.

LABORATORY EXPERIMENTS FOR APPLIED THERMODYNAMICS

Section I

i. **Compulsory practicals**

2. Redwood viscometer
3. Marcet's boiler
4. Calibration of indicator spring
5. Flash point apparatus
6. Thomson's calorimeter
7. Boy's calorimeter
8. Calibration of pressure gauge

Section II

1. flow measuring apparatus
2. Forced vortex
3. Pelton wheel
4. Demonstration of domestic water pump and hydraulic ramp pump.

Three experiments from Section I and II experiments from section II must be completed.

RECOMMENDED BOOKS

1. Engineering Thermodynamics – Work and Heat Transfer
   by G F C Rogers and Y R Mayhew
2. Basic Engineering Thermodynamics in S.I. units by Rayner Joel
3. Thermal Environmental Engineering
   By J L Threlkeld
4. Heat and Mass Transfer
   by E R G Eckert
5. Heat Transfer
   By Alan J Chapman
6. The Internal Combustion Engine in theory and Practice Volumes 1 & 2
   by C F Taylor

RECOMMENDED READING

1. fluid Mechanics (Sections 1,2,3,4, & 5)
   by F M White (McGraw Hill)

2. Fluid Mechanics (Sections 1,2,3 & 4)
   By V L Streeter and E Benjamin Wylie
   (McGraw Hill – International Student Edition)

3. Fluid Mechanics (Sections 1,2,3,4 & 5)
   By J F Douglas, J M Gasiorek and J A Swaffield
   (Longman Scientific & Technical)

4. Physical Fluid Dynamics (Sections 2 & 6)
   By D J Tritton (Oxford University Press)

5. Mechanics of Fluid (Sections 1,4,5 & 6)
   By W J Duncan, A S Thom and A,D Young
   (Edward Arnold Ltd.)

6. Mechanics of Fluids (Sections 1,2,3,4,5 & 6)
   By B S Massy (Van Nostrand Reinhold Company Ltd.)

213. MECHANICS OF MACHINES

Lectures = 80 hours

Power transmission 06 hrs

Methods of power transmission available, descriptive treatment and elementary analysis of positive, friction, electro – mechanical and fluid drives.

Belt drives 08 hrs

Power transmission via belts; friction formulae for flat and V-belts, centrifugal tension, initial tension, creep and slip. Band brakes and dynamometers.

Toothed gearing 08 hrs

Spur gearing between parallel shafts, external and internal gearing. Basic definitions and equations. Introduction to epi – cyclic gearing, rotation table method and angular velocity method for determining speed ration. Acceleration of gears and determination of torques.

Governors 10 hrs

Centrifugal and insertia governors. Different types of governors. Controlling force and stability of governors. Sensitivity and frequency of oscillation of governors.

Cams 08 hrs

Different types of cams and cam followers. Methods of finding pitch curves and profiles for radial cams with various types of follower. Desirable follower motions and characteristic curves.

Balancing of reciprocating engines 12 hrs

Out of balance in a slider crank mechanism, partial balancing of single cylinder engines. Primary and secondary balancing of in – line engines, V – engines, radial engines and reciprocating compressors. Direct and reverse crank technique.

Vibration 12 hrs

Free vibration of two D.O.F undamped and damped systems, governing equations, natural frequencies and natural modes. Mechanical systems, Structural systems and torsional systems. Forced vibration of D.O.F. undamped and viscous damped systems.

Motion in 3 – D 16 hrs

Equation of motion of a particle and a system of particles. Motion of a rigid body in 3D, Momentum and the moment of momentum of a rigid body with respect to a fixed frame and a rotating frame. Euler's dynamical equations applied to rotation about principal axes. Gyroscopic couple Applications.

LABORATORY EXPERIMENTS

1. Damped vibration of a liquid colum (3 Hours)
2. Linear vibration (3 Hours)
3. Trifilar and bifilar suspension (3 Hours)
4. Taurning moment (3 Hours)

RECOMMENDED BOOKS

1. Statics and Dynamics
   By J L Meriam (John Wiley and Sons Inc.)

2. Theory of Machines
   By Thomas Bevan

3. Applied Mechanics
   By J Hannah and M J Miller (Longman)

4. Vector Mechanics for Engineers – Dynamics
   By F P Beera and E R Johnston, Jr. (McGraw Hill)

5. Mechanics of Machines
   Advanced Theory and Examples
   By John Hannah and R C Stephens
   Second Edition SI Units
   (Edward Arnold)

214. STRENGTH OF MATERIALS

Lectures = 80 hours

Analysis of stress 06 hrs

Definition of stress at a point; Three – dimensional states of stress; Mohrs' circle for three – dimensional stress maximum shear stresses in the case of three dimensional principal stresses. Equations of equiliorium.

Analysis of strain 06 hrs

Definition of strain in terms of displacements; Equations of compatibility; State of strain at a point; principal strains.

Theory of elasticity 10 hrs

Generalized Hooke's Law; Two – dimensional problems in Elasticity; Plane strain problems; Plane stress problems; Stress function and its applications; Basic relations in elasticity in polar coordinates.

Bending stress 10 hrs

Elastic stresses in beams due to shearing force and bending moment; Bending of asymmetrical sections; Principal axes of bending; Composite beams.

Combined bending and axial force; Elastic columns; Middle third rule for rectangular sections; Middle quarter rule for circular sections.

Theories of Elastic Failure 06 hrs

Theories of failure by yielding; Maximum principal stress theory; Maximum principal strain theory; Maximum shear stress theory; Maximum distortion energy theory; Comparison and applicability of yielding theories.

Plasticity 06 hrs

Theory of plastic bending; Analysis of perfectly plastic beams; Plastic hinge; Collapse loads; Elastic plastic beams; Plastic hinge; Collapse loads;

Cylinders & Spheres 10 hrs

Thin cylinder under internal pressure; Thin spherical shell under internal pressure; Cylindrical shell with hemispherical ends; Volumetric strain.

Thick walled cylinder under internal and external pressure; Shrink fitted cylinders; Hub shrunk on solid shaft

Rotating disus 06 hrs

Rotating disus of uniform thickness; Solid discs; discs with central holes; Rotating discs and rings with radial pressure.

Torsion of prismatic bars 10 hrs

Torsion of circular sections; Torsion of non – circular sections, Torsion of thin walled open sections; closed tubes of non – circular sections; Cellular sections; Membrane analogy. Elastic – Plastic torsion.

Mechanical testing of Materials 08 hrs

Testing machines; Methods of testing; Selection of test pieces; Tensile, hardness and impact properties; Tensile – Plastic instability and its meaning in tensile test.

LABORATORY EXPERIMENTS

1. Hardness testing
2. Tensile testing of metallic materials
3. Impact testing of metals
4. Determination of Young's modules & modules of rigidity of metals
5. Deflection of cantilever beams
6. Torsion of prismatic bars
7. Verification of reciprocal theory

It is recommended that at least four (04) practicals be performed by the students.

RECOMMENDED BOOKS

1. Theory of Elasticity
   by S Timoshenko and J Goodlier (McGraw Hill)]

2. Strength of Materials
   by G H Ryder (Macmillan)

3. Theory of Flow & Fracture of Solids
   by A Nadal (McGraw Hhill)

4. Plasticity for Mechanical Engineers
   by W Johnson and P B Mellor (von Nostrand)

5. Mechanical Testing of Materials
   by A J Fenner (Newnew)

215. PRODUCTION TECHNOLOGY

Lecture - 80 hours

Metrology 12 hrs

Basic Standards of length and angle, Effects of shape and size errors.

Measurement and Gauging, Sources of measurement error.
Limits and fits for plain components.
Taylor's principle of gauging.
Description of measurement of surface finish

Metal Cutting 16 hrs

Metal removal and surface finishing processes.
Mechinability Criteria and Methods of Evaluation

Geometry and mechanics of orthogonal cutting. Shear plane and shear zone models. Thermodynamics aspects.

Modes and criteria of tool wear and prediction of tool life.
Optimisation of machining process.
Basic design features of machine tool structures and elements. Static and dynamic characteristics.

Metal forming 16 hrs

Ideal deformation friction and redundant work.
Strain rate effects, Tresca and Von Mises yield criteria.
Introduction to slip line theory. Plane strain indentation and plane strain deformation. Treatment of specific forming processes: Cold working. Hot working. Rolling. Forging, Wire and Tube forming

Joining 10 hrs

Principles and technology of fusion and solid phase welding including hot/cold, pressure, friction, ultrasonic.
Design for joining, Properties of joints and the Control of joint quality.
Standards in joining.
Joining economics and Process selection

Casting 10 hrs

Casting processes: Selection and Comparison
Solidification processing, Control of casting quality
Casting defects. Casting design for production.

Computer aided manufacture 16 hrs

Principles of Numerical control of machine tools

Manual part programming, Computer aided programming
Tools and tooling for NC machine tools.
Industrial robots and work handling systems
Categories of manufacturing systems, Flexible manufacturing cells, Flexible manufacturing systems.

LABORATORY EXPERIMENTS

1. simple measurements – Line, end, and angular measurements
2. Use of Comparator
3. Measurement of cutting forces using, lathe tool dynamometer
4. Influence of cutting speed on tool wear and tool life.
5. Dependence of chip compression factor on cutting conditions
6. State acceptance test for a centre lathe
7. Manual part programming
8. Computer aided part programming

It is recommend to perform at least five (05) practicals. IESL may decide in consultation with the Lecturer.

RECOMMENDED BOOKS

1. production Engineering Technology
   by J D Radford and P B Richardson

2. Principles of Engineering Production
   by A J Lissaman (ICS)

3. Workshop Technology – Parts I, II and III
   by W A J Chapman (Edward Arnold)

4. Mechanical Measurements
   by Beekwith Thomas and Buck N Lewis (Oxford and IBH Publishing Co.)

5. Manufacturing Technology Volumes 1 and 2
   by R L Timings (Longman higher Education)

6. Production Technology
   by R K Jain and C S Gupta(Khanna Publishers)

7. Advanced Methods of Machining
   by J A Mc Geough (Chapman & Hall)

8. An Introduction to CNC Machining
   by David Gibbs (Cassell)

9. CAD/CAM: Computer Aided Design and Manufacturing
   By Groover and P Mikell (Prentice Hall)

10. Computer Integrated Manufacturing
    By P G Ranky (Prentice Hall)

216. MATERIALS ENGINEERING

Lectures = 80 hours

Structure of Materials 06 hrs

Crystalline materials (metals, ceramics) and Amorphous materials (glass, polymers)

An overview on type of bonding, molecular and crystal structure, general physical and mechanical properties.

Ceramics and Glasses 10 hrs

Structure, Properties, and fracture of ceramics
Production and forming methods
Cements an Concretes.

Polymeric Materials 10 hrs

Types of polymers: Thermoplastics, thermosets, and elastomer.

Structure and Properties of Polymers; Addition and condensation polymers, co-polymers, cross-linked polymers, degree of polymerisation, molecular weight, molecular weight distribution, crystallinity, glass transition temperature. Physical, Chemical, and Mechanical Properties of polymers.

Forming and Moulding Methods: Extrusion, injection moulding, compression moulding, vacuum and blow moulding.

Composites 10 hrs

Fibre Reinforced composites; Types of strong fibres and their physical properties production of strong fibres, manufacture of fibre reinforced composites such as metal matrix, polymer – Matrix and ceramic – Matrix composites. Mechanics of fibre reinforcement.

Timber: Structure, deformation and strength characteristics, preservation, defects in word.

Forming of Metals 10 hrs

Metal Casting : Solidification theory, cast structure, casting defects, annealing effect on microstructure.
Shaping of Metals : Deformation characteristics and microstructural changes during cold working and hot working processes.
Annealing of Deformed metals: Microstructure development during recovery, recrystallization, and grain growth, and the changes in properties.

Ferrous and Non – Ferrous Alloys

Steel : Plain carbon steels, equilibrium and non-equilibrium microstructures, effect of alloying elements.
Heat treatment of steels: Normalizing, aneealing, quenching, and tempering, hardenability of steels, TTT diagrams, continuous cooling curves.

Stainless Steel: Effect of Cr and Ni on the corrosion resistance. Types of stainless steel, such as : ferritic, austenitic, and martensitic.
Cast Iron : Manufacture of cast iron, effect of alloying elements. Grey cast iron, white cast iron, nodular cast iron, maileable iron.
Aluminium Alloys : Cast and Wrought Alloys, effect of alloying elements. Copper Alloys : Alloys used for cast products and their applications.

Wrought alloys and their applications. Nickel and Cobalt based alloys.

Strengthening Mechanisms

Grain boundary strengthening, solid solution strengthening, precipitation and dispersion hardening, work hardening, and quench hardening.

Corrosion of Metals

Oxidation, electrochemical nature of corrosion, corrosion mechanisms: galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion and stress corrosion.

Methods of corrosion prevention : Selection of Materials, desing, anodi and cathodic protection, application of coatings, electroplating.

RECOMMENDED BOOKS

1. The Elements of Materials Science, L H Van Vlack, Addision-Wesley
2. Materials Science, J C Anderson and K D Leaver, Van Nostrand Reinhold, New York.
3. Introduction to Engineering Materials, V B Joh, Macmillan.
4. Properties of Engineering Materials, R A Higgins, Hodder and Stoughton _ London.
5. Introduction to Manufacturing Prcesses, J A Schey, McGraw-Hill Co.
6. Corrosion Engineering, M G Fontana and N D Greene, McGraw Hill Co.

PART THREE A

List of Subjects

No	
301	Mathematics
302	Structural Analysis
303	Civil Engineering Construction
304	Water Engineering
305	Geotechnical Engineering
306	Structural Design – Prestressed Concrete and Steel
307	Electrical Machines II
308	Power Systems II
309	Electronic Systems Engineering
310	Communication Systems Engineering
311	Computer Systems Engineering
312	Mechanics of Solids
313	Dynamics of Mechanical Systems
314	Applied Thermodynamics
315	Highway & Traffic Engineering
316	Environmental Engineering
317	Irrigation and Water Power Engineering
318	Building Services Engineering
319	High Voltage Engineering
320	Power Electronics and Applications
321	Physical Electronics
322	Operational Research
323	Control Systems Engineering
324	Machine Design
325	Manufacturing Systems Engineering
326	Software Systems Engineering

PART THREE B

No	
327	Engineering Management

PART THREE C

Project Report

Civil Engineering Stream

5 Compulsory Subjects and any one optional

	Number of Hours	
	Lectures	Practicals
302. Structural Analysis	80	18
303. Civil Engineering Construction	80	18
304. Water Engineering	80	18
305. Geotechnical Engineering	80	18
306. Structural Design – Prestressed Concrete and Steel	80	18

Optional

	Number of Hours	
	Lectures	Practicals
315. Highway & Traffic Engineering	80	
316. Environmental Engineering	80	
317. Irrigation and Water Engineering	80	
318. Building Services Engineering	80	

Mechanical Engineering Stream

4 Compulsory Subjects and any Two optionals

	Number of Hours	
	Lectures	Practicals
301. Mathematics	80	
312. Mechanics of Solids	80	
313. Dynamics of Mechanical Systems	80	
314. Applied Thermodynamics	80	24+16*
* Project Work in Machine Design		24

Optional

	Number of Hours	
	Lectures	Practicals
322. Operational Research	80	
323. Control Systems Engineering	80	12
324. Machines Designs	80	12
325. Manufacturing Systems Engineering	80	

Electrical Engineering Stream

4 Compulsory Subjects and any Two optionals

	Number of Hours	
	Lectures	Practicals
301. Mathematics	80	
307. Electrical Machines II	80	24
308. Power Systems II	80	24
309. Electronic Systems Engineering	80	18

Optional

	Number of Hours	
	Lectures	Practicals
311. Computer Systems Engineering	80	12
319. High voltage Engineering	80	12
320. Power Electronics & Applications	80	12
323. Control Systems Engineering	80	12

Electronic Communication & Computer Engineering Stream

4 Compulsory Subjects and Two optionals

	Number of Hours	
	Lectures	Practicals
301. Mathematics	80	
309. Electronic Systems Engineering	80	24
310. Communication Systems Engineering	80	24
311. Computer Systems Engineering	80	18

Optional

	Number of Hours	
	Lectures	Practicals
320. Power Electronics & Applications	80	12
321. Physical Electronics	80	12
323. Control Systems Engineering	80	12
326. Software Systems Engineering	80	

Part III B

Number of Hours

	Lectures	Practicals
327. Engineering Management	80	-

Part III C

Project Report

301 MATHEMATICS

LECTURES = 80 HRS

Mathematical Methods 12 hrs

Complex variables : analytical functions and Cauchy – Riemann equations. Cauchy's integral formula and applications.
Taylor and Laurent series. Contour integration. Introduction of conformal mapping.

10 hrs

Partial differential equations : classification of second-order partial differential equations. Solutions by separation of variables. Fourier series application to boundary value problem.

08 hrs

Fourier Transform and applications : Nonperiodic function, fourier transform, properties of fourier transform and applications.

Probability and Statistics

20 hrs

Discrete and Continuous variate, Expectation, mean and variance of Binomial, poisson, Exponential, Normal Distribution. Estimation, sampling distribution, central limit theorem. Confidence intervals for mean and variance. Hypothesis tests for mean, proportions, variance , difference between proportion, means and variance including T and F-tests. The goodness-of-fit test and contingency tables. Scatter diagrams, regression, correlation, least squares estimation and hypothesis tests in linear regression.

Numerical Methods

20 hrs

Solution of sets of non-linear equations Numerical optimization problems (direct search and simple gradient methods. Matrixe cigenvalue and eigen value determination including direct and inverse iteration and shift of simple finite difference techniques for initial-value and boundary-value problems in ordinary and partial differential equations and systems. Phase plane and isoclinal curves. Taylor series, Runge – Kutta process. Explicit and implicit procedures, simple ideas on errors and stability introduction to method of characteristics.

Computing

10 hrs

Working knowledge of programming in one high-level Language (e.g. Fortran, Basic or Pascal), including sub-programs, arrays and subscripts, strings and graphics. Use of computer packages. Algorithms , Flow diagrams Applications in Numerical Methods and Statistics.

RECOMMENDED BOOKS.

1. Advance Mathematics for Engineers & Scientists by G S Sharma, K L Ahuja and I J S Sarma, CBS Publishers New Delhi. Vol. I & II. (Multiple Copies)
2. Mathematics for Engineers and Scientist by Alan Jefferey
3. Schaum's Outline series books on

Matrices	Linear Algebra	Vector Analysis
Calculus	Advanced Calculus	Differential Equations
Numerical Analysis		

4. Advanced Engineering Mathematics by A C Bajpai , L R Mustoe, D Walker (Multiple Copies)

302 Structural Analysis

Lectures = 80 hrs

Matrix methods in Structural Analysis

12 hrs

Matrix Flexibility method :
Flexibility approach in structural analysis, degree of statistical indeterminacy, member flexibility matrices, temperature effects, yielding of supports

Matrix stiffness method:
Degree of kinematic indeterminacy, elements stiffness matrices for bar and beam elements, structure stiffness matrix, local and global co-ordinate systems, co-ordinate transformation, application of boundary conditions , plane trusses, plane frames, grillages and space frames.

Introduction to Finite Element Method (FEM) 10 hrs

Concept of strain energy , potential energy of applied loads and total potential energy (IIP), principle of minimum potential energy (PMPE), variational principle, Rayleigh-Ritz method, finite element formulation for simple bar and beam elements, plane stress and plane strain, initial stress and strain effects.

Theory of Thin plates 10 hrs

Governing equation for rectangular and circular thin plates, boundary conditions, stress resultants, Navier solution , Finite difference method.

Theory of Thin Shells 10 hrs

Membrane theory for thin shells, shells of revolution ,bending theory for closed circular cylindrical shells, boundary conditions.

Stability of Frameworks 10 hrs

General principles and criteria of elastic instability , instability of struts and frames, Eular load for pin ended struts and effects of other end conditions. Effects of initial curvature, stability functions, estimation of critical loads using stability functions.

Plastic Theory 10 hrs

Plastic hinge and collapse concepts, Static , kinematic and uniqueness theories, collapse mechanisms, methods of plastic design, load factor against collapse.

Yield Line Theory 10 hrs

Behaviour of slabs near collapse, yield line patterns, yield moments , work method of analysis, equilibrium method of analysis, affinity theorems.

Structural Dynamics 08 hrs

Vibration problems in Engineering, free and forced vibration, single degree of freedom system and systems with few degrees of freedom.

LABORATORY EXPERIMENTS

1. Timber testing
2. Cement mortar testing
3. Concrete mix-design
4. Tests on concrete
5. Aggregate testing
6. Computer analysis of structures (using packages)

RECOMMENDED BOOKS

1. Structural Analysis (a unified classical & matrix approach), A Ghali, AM Neville, Chapman & Hall, London
2. Matrix Methods of Structural Analysis, R K Livesley, Pergamon Press, Oxford
3. Finite Element Method : An Introduction for the Engineer , R K Livesley , Cambridge University Press
4. Theory of Plates and Shells, S P Timoshenko, S Woinowsky – Krieger, McGraw Hill, New York
5. Thin Shells – Computing and Theory , J E Gibson Pergamon Press Oxford
6. Structural Analysis, RC Coates , MG Coutie, FK Kong, Chapman & Hall, London.

303 Civil Engineering Construction

Lectures = 80 hrs

Planning and Setting out : 08 hrs

Site Preparation and Services : Setting out of structures .

Land clearing and Earthworks 14 hrs

Equipment used for Land clearing and earthworks : Bulldozer, Back-Hoe, Grab, Scraper, Grader, Wheel Loader, Dredger, Dump Truck; Land clearing techniques; Large excavations, dredging, Trench excavation, Pipe laying, De-watering, Sheet piling and Shoring Systems.

Compaction of Earth 08 hrs

Grading of soils; Equipment used for compaction; compacting techniques.

Concrete Technology 10 hrs

Properties of Concrete; concrete materials, Mix design, quality control, reinforcement , construction joints, plasters and mortars, precast concrete and tolerances, prestressed concrete.

Concreting Material handling on sites and access scaffolds 10 hrs

Material handling equipment on site: Hoists, Forklifts, Tower cranes ; other cranes, Dumpers, site layout of material handling equipment; form work, concreting equipment and methods, Erection of scaffolds.

Tunneling Rock Blasting and Aggregate Production 10 hrs

Tunnelling equipment and methods, Blasting of rock and use of explosives, quarrying and production of aggregates.

Road and Bridge construction 10 hrs

Road Construction techniques; earthmoving plant selection ; Bridge construction methods; cofferdams and work over water ; Pile driving and Caission sinking.

Introduction to Repair of structures and demolition work 06 hrs

Methods used for repair and renovation ; Equipment and techniques used in demolition work.

Construction Safety 04 hrs

Safe construction practices and checklists.

LABORATORY EXPERIMENTS

1. Setting out of a building, tunnel, bridge or any other civil engineering structure giving details of surveying equipment used, procedures adopted and so forth.
2. Planning and execution of a road construction including site mobilization, preparation of site, site facilities, plant selection for various operations and construction methods.
3. Planning and execution of bridge construction including site mobilization, preparation of site, site facilities, plant selection, construction methods including coffer dams, sheet piling and work under and over water.

RECOMMENDED BOOKS

1. Peurifoy, R L "Construction Planning, Equipment and Methods", McGraw Hill 1985
2. Harris, F, "Modern construction equipment and methods "' Longman Scientific & Technical copulbished in the USA with John Willy and sons Inc, New York, 1989.
3. Murphy, R W , "Site Structural Analysis (a unified classical & matrix approach), A Ghali, AM Neville, Chapman & Hall, London
4. Shapiro, Howard I, "Cranes and Derricks", McGraw Hill Inc. 1991.
5. Harris, Frank. "Ground Engineering Equipment and methods". Granada Publishing , 1983.
6. Russel, James E. "Construction Equipment" Reston Publishing Co. , Inc, USA, 1985.
7. Sadgrove, B.M. "Setting – out procedures", Butterworths, CIRIA, 1988.

304 Water Engineering

Lectures = 80 hrs

Non-Uniform Flow in Open channels 14 hrs

Specific Energy – Variation of specific Energy with Depth at constant discharge and with discharge at constant Head- Critical Depth – super critical and sub critical Depths – Alternate Depths – Determination of surface profiles by numerical, graphical and analytical methods, Hydraulic Jump on horizontal bed – Initial Depth & Sequent Depth – Loss of energy in a Hydraulic Jump – flow from a Reservoir to a Channel – Flow between two Reservoirs – Branching Channels - Flow at a Clear overfall.

Hydraulic Structures 06 hrs

Introductory description and calculation of discharge for Flumes, Sluices, (With free flow and submerged flow), weiers (sharp crested, ogee type and broad crested), spillways (weir type- morning glory and siphon types)-Energy Dissipators.

Sediment Transportation 06 hrs

Modes of Sediment Movement, Suspended Load, Bed Load, Stable Channel

Design of Channels 06 hrs

Design of Channels in Erodible and Non Erodible, Material Criteria for Design – Economic section – Maximum and Minimum permissible Velocities – Maximum Permissible Unit Tractive Force – Cohesive and Granular Materials.

Surface Water Hydrology 26 hrs

Introduction of the Hydrological Cycle, Precipitation : Measurement of Precipitation – Estimation of Missing Data – Tests for consistency of Data – Hyetograph –Pluviograph- computation of Mean precipitation over a given area from gauge measurements using simple average, Theissen polygon and Isohyetal Methods – Intensity/ Frequency/ Duration Curves.

Run Off : Measurement of Run – off – flow rating curve - correction of flow rating curve- extension of flow rating curve – Statistical Analysis of floods –Probability and Return Period – flood Frequency Analysis – gumbel and Normal distributions – Rational Formula – Run-off Coefficient – Time of concentration.

Hydrograpy analysis : Separation of Base Flow – Infiltration – Index W Index – Estimation of Net Rainfall and surface Run-off Unit Hydrograph Theory - Derivation of Unit Hydrography form Natural Hydrography – Conversion of Unit Hydrograph from one duration to another – S Curve Instantaneous Unit Hydrography – Derivation of IUH from Unit Hydrograph and Vice-versa-Synthetic Unit Hydrograph Snyder's Method.

Design and Operation of Reservoirs : Use of the mass curve in Reservoir Capacity, Spill volume and Sustainable Yield Studies.

Flood and Reservoir Routing : Simple techniques of Routing a flood Hydrogrph through a Reservoir and through a section of channel – Muskingum Method.

Groundwater Hydrology 12 hrs

Introduction to Groundwater as a component of eth Hydrological Cycle – Types of Aquifers – Igneous, Metamorphic and Sedimentary formations – Non indurate sediments.
Equations of Ground water Flow in Carteseian and Radial Co-ordinates for Steady and Unsteady Flow including recharge and abstraction – Boundary and Initial Conditions – Steady State Flow in Confined and Unconfined Aquifers with Cartesian Coordinates (one dimensional only) and radial coordinates .
Jacob's Method – Theis Method – Analysis of Recovery Data.
Introduction to Groundwater Models – Finite Difference Digital Models – Electrical Resistance Capacitance Models.

Coastal Engineering 10 hrs

An Introduction of the Coastal Environment – Brief Description of the Random Sea state – Methods of wave Height Measurement – Brief Survey of Linear and Non Linear wave theories.

Linear Wave Theory : Laws governing the motion of fluids – Boundary Conditions – Development of Velocity Potential - Kinematics and Dynamics of Sinusoidal Progressive Waves in Constant water depth – period, Celerity and Length of waves – Classification of Water waves according to water depth (deep and shallow water approximations) – Water particle velocities and displacements - - Group Velocity, Potential and Kinetic Energy – Total Energy Pressure within a Progressive Wave.

Transformation of Waves : Shoaling – Refraction and Breaking of Waves – Refraction by Currents – Diffraction of Waves – Reflection of Waves.

Note : It is recommended that the wave Tables in the Shore Protection manual of the U.S. Corps of Engineers be used for computations in relevant sections in coastal Engineering.

LABORATORY EXPERIMENTS

1. Determination of surface profiles in Non Uniform Flow in a channel.
2. Determination of Initial and Sequent Depth, Length of Jump, Energy Loss and location of Hydraulic Jump.
3. Field Measurement of Infiltration Capacity.
4. Measurement of Stream Flow in the field.
5. Use of Computer Models for simulation of Run off from Rainfall data.
6. Pumping test of a borehole.
7. Electrical Resistance Analogue Model for Aquifer Simulation.

RECOMMENDED BOOKS

1. Open – Channel Hydraulics, Ven Tel Chow, Mc Graw –Hill
2. Open Channel flow, F.M. Henderson, Macmillan
3. Flow Through Open Channels, K G Ranga Raju, Tata McGraw – Hill
4. Engineering Hydrology, K Subramanya, Tata McGraw – Hill
5. Groundwater Hydrology, D. K . Todd, John Wiley
6. Engineering Hydrology , E.M. Wilson , ELB
7. Estuary and Coastline Hydrodynamics, A.T. Ippen et al., McGraw – Hill
8. Hydrology for Engineers, R . K. Linsley, M. A . Kohler and J. L H. Paulhus, McGraw – Hill.

305 Geotechnical Engineering

Lectures = 80 hrs

Flow nets 04 hrs

Flow nets for confined and unconfined flow , isotropic and anisotropic conditions.
Critical hydraulic gradient and piping.

Elastic stress Distributions in Soils 02 hrs

Elastic theory of distribution of vertical pressure. Newmaks and Fadum's charts. Limitations of stress distribution theories. Estimation of elastic settlement.

Consolidation of Soils 12 hrs

Concept of consolidation and settlement. Terzaghi's theory of one dimensional consolidation. Laboratory consolidation test, determination of coefficient of consolidation, coefficient of volume compressibility and compression index co, e vs log p plot. Concept of degree of consolidation. Use of laboratory test results estimate rate and amount of settlement in the field. Secondary consolidation.

Shear Strength 12 hrs

Effective and total stresses; Mohr-Coulomb failure criterion in terms of effective and total stresses, c, parameters. Methods of determination of shear strength parameters in the laboratory, direct and triaxial shear tests, unconfined compression test. Different types of triaxial tests and use of their parameters in the field, short term and long term behaviour. Peak and residual strength. Pore pressure parameter. Vane shear test for field determination of shear strength.

Lateral Earth Pressures and Earth Retaining Structures 14 hrs

Earth retaining structures – purpose and different types, Gravity – Mass concrete, masonry, crib walls gabion walls. Embedded walls – sheetpile, concrete diaphragm and bored pile walls, reinforced earth etc.

Computation of earth pressure ;

Active and passive rankine states. Bsic equations, slip lines, influence of surcharge, tension crack.

Influence of friction on wall back, coulombus method of analysis. Effects of seepage, influence of drainage behind walls. Passive resistant of rough walls.

immediate and long term considerations, Use of code (BS-CP 2) equations to estimate earth pressures.

Design of gravity retaining structures, Flexural Retaining structures – Cantilevered and laterally supported. Method of fixed earth support, Rowe's moment reduction factors.

Slope Stability Analysis 14 hrs

Need to quantify stability of slopes, modes of slope instability. Methods of analysis of slope instability; Homogeneous slopes – Friction circle method and Taylor's stability charts, Stratified slopes - Swedish slices method, Bishop's simplified method, Wedge methods. Time dependence of stability – short term and long term behaviour.

Foundations 10 hrs

Types of foundations – Shallow foundations, deep foundation. Requirements for satisfactory foundations; Shallow Foundations, ultimate bearing capacity, Bearing capacity equations Terzaghi's bearing capacity factors, Short Term and long term stability, Bearing capacity in stratified soils, allowable bearing capacity, Estimation of settlements in sands by standard penetration test, Pressuer distribution under foundations rigid analysis , flexible analysis, Design of foundations with and without soil structure interaction – Applications to combined footings and raft foundations.

Deep foundations : 06 hrs

Requirements for satisfactory foundations : Different types of pile foundations with their advantages, disadvantages and uses ; determination of bearing capacity of a single pile, Dynamic or pile driving formulae, and pile load tests; settlement computation of a single pile, carrying capacity of a pile group, settlement computation of pile groups, Negative skin friction.

Basic Rock Mechanics 04 hrs

Engineering properties of Rock Materials, Engineering classification of rock; Rock Mass, Influence of joints and fractures, Strength characteristics, Laboratory measurements of engineering properties.

LABORATORY EXPERIMENTS 09 hrs.

Soil Mechanics – Laboratory classes (3 classes)

Consolidation Test
Direct Shear Test
Triaxial Test

RECOMMENDED BOOKS

Soil Mechanics

Principles of Geotechnical Engineering by Borja M Das, PWS-KENT Publishing Company.
Principles of Foundation Engineering Borja M Das, PWS-KENT Publishing Company.
Soil Mechanics for Civil and Mining Engineers by G N Smith, Granada Publication
Soil Mechanics – R F Graig, Van Nostrand Reinhold Company Ltd

Engineering Geology

Geology of Sri Lanka by P G Cooray

Introduction to Physical Geology by P Zumberg, Elsevier Publication

Geology and Engineering by R Bower, Elservier Publication

Fundamentals of Engineering Geology by F G Bell, Butter and Tanner Publications

Engineering Geology and Geotechnics by F G Bell, Newnes Butterworths Publication

306 Structural Design – Pre-stressed Concrete and Steel

Lectures = 40 hrs

Introduction to Pre-stressed Concrete 12 hrs

Basic Principles : concept of Pre-stressing – historical development advantages and disadvantages, applications of pre-stressed concrete.

Different Types of Pre-stressing : Pre Tensioning & post tensioning, internal & external pre-stressing , bonded & non bonded pre-stressing.

Behaviour of a pre-stressed concrete member I bending :
Basic phases of loading service load behaviour, overload behaviour – (Cracking Load & ultimate load)

Tendon Profile : Eccentricity of prestressing force, variation of prestress , debonding , deflected tendons.

Concepts used in design : Full prestressing & partial prestressing, classification of prestressed concrete members, load balancing technique.

Materials used in prestressed concrete :
Properties of concrete : Compressive strength, stress – strain curve, modules of elasticity, creep & shrinkage.
Steel for pre-stressing : Types and properties, relaxation of steel, stress-strain curve.

Prestressing systems & anchorages : Different types, bursting force anchorage zones, transmission length

Introduction to prestress losses.

Flexural Design for Serviceability limit state. 12 hrs.

Important phases in loading for pre-stressed concrete members, stress distributions and allowable stresses under service and transfer conditions, stress criterion of SLS design.

Selection of section
Expressions for minimum section modulus.
Design of presetressing force-Magnel diagram.
Permissible tendon zone.]
Arrangement to tendon; cover & spacing requirements.
Flow chart for design of PC members.

Loss of Prestress 03 hrs

Estimation of prestress losses (Short term & long term)

Ultimate limit state in bending 02 hrs

Ultimate load behaviour: simplified stress block, variation of steel stress, calculation of moment capacity, strain compatibility method, code formula & tables.

Design for Shear 02 hrs

Failure modes in shear, shear capacity of uncracked and cracked sections, design of shear reinforcement.

Deflections 01 hr

Deflections limits, short term and long term deflections.

Composite construction 02 hrs

Types of composite construction ; loading stages and stress distributions; design of composite beams; flexural strength; horizontal & vertical shear; differential; shrinkage, propping & continuity.

Design Examples 06 hrs

Pretensioned member

Post tensioned member

STEEL

Introduction **06 hrs**

Introduction to steel as a structural material, Applications of steel, Types of steel sections, productions of structural steel, composition and properties of structural steel, corrosion and corrosion protection.

Limit state design of structural steel work 02 hrs.

Basis of design, structural codes, limit states and partial safety factors, design strength of different grades, load combinations.

Design of tension members 02 hrs

Types and uses, types of sections used, net area and effective area, tensile capacity of members, eccentric connections, Examples.

Design of compression members 08 hrs

Compression members in different structures, sections used, behaviour and failure modes of compression members, classification of cross sections, effective length , slenderness limits, capacity of axially loaded columns, laced and battened struts, discontinuous struts, Examples.

Design of Flexural Members 12 hrs.

Types and uses, sections used, failure modes in flexure classification of beam cross sections, in-plane bending of beams, moment capacity, shear in beams, lateral torsional buckling, effective length, design approach, design of built-up sections, local buckling effects in beams, web stiffeners, examples.

Members under combined axial load and moment 02 hrs.

Types and uses , combined tension and bending combined compression and bending , Biaxial bending.

Design of connections 08 hrs.

Types of Connections : Welded and bolted connections Modes of failure, general principles of connection design, capacity of connections, connections in structural work : beam to beam column to column, beam and column splices, truss connections .

Course work :

Course work must include load evaluation element design and connection design of a steel structure.

LABORATORY EXPERIMENTS

Pre-stressed concrete design course work must include the design of a highway bridge deck, a gantry girder, a pedestrian bridge deck or floor beam as a class 1 or class 2 pre-tensioned or post tensioned member.

The course work must include

1. Load evaluation
2. Selection of a section
3. Selection of prestressing force using Magnel diagram
4. Tendon zone and tendon arrangement
5. calculation of prestress losses
6. Check for ULS of flexure
7. Design for shear
8. Check for deflection
9. Detailing

RECOMMENDED BOOKS

Steel Design

(1) BS : 5950 : Structural use of steel work in buildings ; Part I : Code of Practice for Design Simple & continuous construction : Hot Rolled Section. British Standards Institute.
(2) Steel Designers Manual (5^{th} Edition)
Steel construction Institute
(3) Steelwork Design Guide to BS 5950 : Part I Vol. 1 : Section Properties, Member Capacities. The Steel Construction Institute, Ascot 1987
(4) Steel work design guide to BS 5950 : Part I Vol. 2 : Worked Examples. The Steel construction Institute, Ascot 1986
(5) T J MacGinley & T.c. Ang.
Structural Steelwork : Design to Limit State Theory – Second edition, Butterworth – Heinmann 1992
(6) L H Martin & J A Purkiss
Structural Design of Steelwork to BS 5950 Edward Arnold 1992
(7) N S Trahair & M S Bradford
The Behaviour & Design of Steel Structures, Chapman & Hall 1988
(8) T Draycott , Structural Elements Design Manual (Heinemann Newnes)
(9) L J Morris & D R Plum, Structural Steelwork Design to BS 5950
(10) D A Nethercot, Limit State Design of Structural Steelwork (Chapman Hall)
(11) S A Lavan & B G Fletcher, Students Guide to Structural Design
(Butterworths)

Pre-stressed Concrete Design

(1) B S 8110 Part I & 2 (British Standards Institute)
(2) Handbook on BS 8110 : (Viewpoint publications)
(3) F K Kong & R H Evans , Reinforced and Pre-stressed Concrete (Nelson)
(4) M K Hurst, Per-stressed Concrete Design (Champman & Hall)
(5) P W Abeles & B K Bardhan – Roy & Turner, Pre-stressed Concrete Designer's Manual (View point)
(6) A H Nilson, Design of Pre-stressed concrete (John Wiley)
(7) N Krishna Raju, Pre-stressed Concrete (Tata Mc Graw Hill)
(8) A H Allen , an Introduction to pre-stressed Concrete (Cement & Concrete Association)
(9) A E Naaman, Prestressed Concrete Analysis and Design
Fundamentals (McGraw – Hill Book company)
(10) M P Collins & D Mithell, Pre-stressed Concrete Basics (Canadian Prestressed Concrete Institute)
(11) R F Warner & K A Faulkes, Pre-stressed Concrete (Pitman Australia)

307 Electrical Machines II

Lectures = 80 hrs

Design concepts of Machines 06 hrs

Main Design parameters and their relation to machine performance ; electric and magnetic loading; output power equations of ac and dc machines ; factors affecting size of machine; choic of specific loadings, no. of poles, diameter and length of core, air gap length, standard frames.

AC Windings 08 hrs

Electrical Angle, Emf Polygon, phase grouping, phase spread, advantages of double layer windings over single layer windings arrangement of double layer integral slot windings, short pitched windings, selection of number of parallel paths per phase. Flux per pole, induced emf of concentrated fully pitched windings, distribution factor pitch factor and winding factor : all these of fundamental and harmonics, effects of harmonics Mmf distribution of concentrated and distributed windings, effects of short pitching on mmf.

Synchronous Machines 14 hrs

Construction of hydro generators and turbo-alternators; equivalent circuits for cylindrical rotor and salient pole types (two – axis theory), operating characteristics, power factor control, v-curves, power angle characteristics, synchronizing power , concept of stability, hunting and damper windings, measurement of Xs, Xd, Xq; effects of saturation on synchronizing to infinite bus bars ; power sharing between parallel generators; excitation systems ; transient behaviour of synchronous generators.

Low Power machines 12 hrs

Single – Phase induction Motor
Types : construction, operating principle, starting and running performance, determination of capacitance for maximum torque, limitations for the machine, areas of application.

AC Commutator Motor
Construction, operating principle, starting and running performance, areas of application.

PM Brushless de motor
Construction : operating principles, controlling, performance comparison with other types of motors areas of application

Stepper Motor
Construction of different types ; methods of controlling , drive circuits, operating characteristics, areas if application.

Switched Reluctance Motor
Construction, principle of operation, torque characteristics, methods of control , drive circuits, controlling.

Harmonic Aspects of Machines 06 hrs

Harmonic generation by synchronous and induction machines, transformers and power converters, time and space harmonics, harmonics in air gap mmf, harmonic performance of induction, dc, synchronous machines and transformers, their harmonic equivalent circuits.

Introduction to Drives 04 hrs

Comparison of controlled drives, drive specifications load characteristics of common applications, transducers used in a drive, principles of closed loop control, measurement of system parameters such as inertia.

Power Converters 06 hrs

Circuit Diagrams, operating principles, device ratings, controlling methods, dynamic model of following types of power converters, single-phase and three – phase bridge rectifiers (fully and half controlled), dual converter, self commutated dc-dc converters (choppers) classes A-E, Self-commutated dc-ac converters (inverters) voltage source type with PWM operation.

DC Motor Drives 12 hrs

Steady – state operation of separately – excited dc motor fed by rectifiers, armature voltage and field voltage control, rectifiers for 1,2, & 4 quadrant operation of dc motors, continuous and discontinuous conduction, starting and breaking dc series motor drives. Steady – state operation of chopper fed separately – excited dc motors, armature voltage control and field voltage control , pulse width control and current control, current ripple and its effects, switching frequency comparison with rectifier red drives, dc series motor drives
Dynamics and closed loop control, elements and their dynamic models of a closed loop speed control system with inner current loop using a separately excited dc motor, operation of this system for input command changes and load changes.

Transient behaviour of open-loop controlled dc machines analysed using differential equations.

Induction Motor Drives 12 hrs

Variable frequency operation using voltage source and current source inverters, six-step and PWM modes of control, elements of closed loop speed control l system, 1, 2 & 4 quadrant operation, starting and breaking;

Control criteria : Constant volts per Hertz control, torque control, flux control, vector controlled drives.
Variable voltage drives ; drives using wound rotor induction motors (slip power recovery methods)

LABORATORY EXPERIMENTS

1. Steady – state study of a synchronous generator
2. Short circuit transients of a synchronous generator
3. Rectifier fed dc motor drive : open-loop and closed loop control
4. Chopper fed dc motor drive : open and closed loop control
5. Variable frequency induction motor drive : voltage source inverter with six-step wave and PWM operations : current source inverter with six-step and PWM operations.
6. Tests on low power motors : single – phase induction motor, ac commutator motor , stepper motor, PM brushless dc motor, switched reluctance motor
7. Computer simulation of dc moor to study its transient behaviour

308 Power Systems II

Lectures = 80 hrs

Energy Planning and management 20 hrs

Energy economy interaction, GDP elasticity, demand forecasting, policy analysis and energy planning.
Supply side issues of energy management
Demand side issues of energy management, End user energy conservation and efficiency improvement.

Power System Economics and planning 09 hrs

Economic operation of a power system considering transmission losses, merit order loading.
Long term and short term planning
Reliability and probabilistic production costing, Availability, Mean Time to Failure (MTTF)
Loss of load Probability (LOLP), etc.

Power Flow Analysis 15 hrs

Analog methods of power flow analysis
Dc and ac network analysers
Digital methods of analysis
Power flow algorithms and flow charts analysis using iterative techniques
Introduction to modern techniques of load flow analysis, Artificial intelligence applications, etc.

Power System stability 15 hrs

Steady state stability : Power angel diagram, effect of voltage regulation, swing equation.
Transient stability , equal area criterion, stability under fault conditions, step by step solution of swing equation.
Stability and control issues of an isolates small power systems in remote areas or small islands, wind/diesel, hydro/diesel, solar/diesel, etc, Hybrid systems

Power System Control 12 hrs

Generator control
Machine modeling for steady state and transient operation
Active power and frequency control
Reactive power and voltage control
Control characteristics of hydro, thermal, nuclear wind and other different categories of power plants

System Grounding 06 hrs

Ungrounded, effectively grounded, resistance grounded, reactance grounded and resonant grounded systems.
Substation earthing.

Mechanical Characteristics of Overhead lines 06 hrs

Choice of route, types of towers, conductor spacing and configuration. Sag and span calculations, sag templates, stringing charts.

LABORATORY EXPERIMENTS

1. Load Flow analysis :
   Perform a load flow study of a given system using the dc network analyzer, Digital simulation of a given power system and results of load flow analysis.

2. Fault Analysis :
   Use dc network analyzer and digital computer for unbalanced fault analysis of a power system.

3. Transmission studies I :
   Power angle diagram, study of power angle Vs. Power flow along transmission lines, Power factor correction.

4. Transmission Studies II :
   Study of quadrature and in-phase boosting for active and reactive power flow control of parallel transmission lines.

5. Peterson Coil
   Study of arc suppression coil.

RECOMMENDED BOOKS

1. A K Sawhney , A Course in Electrical Machine Design, Dhanpat Rai & sons , Delhi, 5th edition, 1984
2. M G Say, Alternating Current Machines , Longman Scientific & Technical, Essex , 5th Edition, 1983.
3. P S Bimbhra, Electrical Machinery, Khanna Publishers, Delhi, 4th Edition 1992
4. G R Slemon, Electric Machines and Drives, Addison- Wesley Publishing Company Inc., 1992
5. P C Sen, Principles of Electric Machines and Power Electronics, John Wiley & Sons , 1989.

REFERENCE

1. K K Y W Perera, Energy Status of Sri Lanka, Institute of Policy Studies, Sri Lanka (1992)
2. Olle I , Elgerd : Electric Energy Systems Theory, Tata Mc Graw Hioll (New Delhi, New York)
3. V K Mehta, Principles of Power System, S Chand and Co. Ltd, (New Delhi)
4. B M Weedy ": Electric Power Systems , John Wiley 7 Sons (New York)
5. Allan J Wood, Brue F , Wollenbers : Power Generation Operation and Control, John Wiley & Sons (New York).

309 Electronic Systems Engineering

Lectures = 80 hrs

Operational Amplifier Applications 10 hrs

Design of Active Filters, oscillators circuits, comparator circuits, Schmidtt triggersl analog computers.

Power Amplifiers 10 hrs

Principle of Operation of class A, B, AB, C & d power amplifiers, derivation of power efficiency, effects on wave form distortion, power BJTs and MOSFET devices, thermal dissipation, practical circuits, audio power amplifier, HF Power amplifiers.

Power Supplies 10 hrs

Voltage stabilization and regulation, series, shunt and switching types of regulators, principle of operation and practical circuits, IC regulator chips and their applications, DC-DC converters , buck ,boost and buck-boost types, Flyback, half-bridge and full-bridge types, uninterruptible power supplies (UPS), on line, of line and line interactive types.

Special Electronics Devices 08 hrs

Silicon Controlled Rectifiers (SCR) : construction, characteristics and circuits , DIACS and TRIACS : Construction , characteristics and circuits, optoelectronic devices Photodiodes and transistors, LEDS Opto-couplers, LCDs, UJTs and applications in control circuits.

Programmable Logic Devices and Semiconductor Memories 10 hrs

PLDs, : Basic organization, Principles of operation, applications & typical ICs , classification of memories, basic memory cells of ROM, EPROM, EEPROM, static & dynamic RAM, internal organizations, typical pin organization of common memory packages.

Digital to Analog and Analog to Digital convertors 06 hrs

D/A convertors : weighted resistor & R-2R ladder types ; A/D convertors, counter, successive approximation, and flash types, practical circuits and applications, typical ICs.

Microprocessor Systems 16 hrs

Non Neuman model of a computer, LSI and VLSI devices used in microcomputer systems ; CPU Organisation, machine code, assembly programming and high level language concepts ;
Hardware and the architecture of a representative microprocessor, pin organization, interfacing to memory , instruction set, user level registers, assembly programming.

Computer Interfacing 10 hrs

General interface concepts ; common peripherals and their interface circuits (keyboard, printer, VDU), common serial and parallel interface standards; interface buses; IEEE-488 instrumentation bus.

RECOMMENDED BOOKS

1. Bogart, F.G., Electronic Devices and Circuits, Bell & Howell Company
2. Toci, R.J., Digital Systems, Principles and Applications, Prentice Hall.
3. Horowitz, P.& Hill, W ., The Art of Electronics, Cambridge University Press.
4. Millman, J & Grebel, A., Microelectronics, Mc Graw-Hill.

310 Electronic Systems Engineering

Lectures = 80 hrs

Application of Principles 20 hrs

Introduction to communication systems and basic elements, application of Fourier analysis for communication system analysis, application of statistical tools for analysis of noise performance of communication systems, Application of information theory for communication system analysis.

Public Telephone System 20 hrs

Overview of the public telephone system, Types of analog/digital services, Voice /Data services, Types of Wireline/Wirelss communication channels, Principles of Analog transmission, Principles of Digital transmission, Design parameters for transmission channels/ equipment ; Principles of Switching, Evolutions towards ISDN and SDH, Statistical characterization of teletraffic, Grade of service, dimensioning of circuits and switches.

Mobile communication systems 10 hrs

Operation of paging, trunked mobile radio and cellular systems, Base station and mobile station equipment and their operation.

Radio Broadcasting Systems 10 hrs

Use of LF, MF, HF and VHF bands for radio broadcasting, Types of transmitters, antennas, other equipment for radio broadcasting, principles of radio receivers

Television Broadcasting systems 10 hrs

Principles of monochrome and colour TV, NTSC, SECAM and Pal systems, Transmission equipment, TV receivers

Data communication Systems 10 hrs

Circuit and packet switching , Layered architectures, commonly used protocols, Local area networks, and wide area networks.

LABORATORY EXPERIMENTS

Due to the complexity of modern communication systems , mini projects are proposed instead of conventional practicals. A student must do at least two individual mini projects, related to two different types of communication systems, covering a specific item of the system under the supervision of a competent communication lecturer/engineer.

RECOMMENDED BOOKS

Communication systems, third edition – AB Carlson
Analog and digital Communication – Simon Haykin
Principles of communication systems – Taub and Schilling
Television Principles and Practice - - J S Zarach
Mobile communication systems – WCY Lee
Data communication – DC Green
Radio Communication - GG Chawla
Telecommunication Economics – T J organ
Electronic Switching – GRINSEC

311 Computer Systems Engineering

Lectures = 80 hours

Introduction

Historical development: influence of computers on society and industry; basic components of a computer; classification of computers; micros, minis, mainframes, supercomputers, portable computers, very small computers.

General Computer Concepts

Functional operation of information processing machine (digital computer); stored program concept; sequential computers; von-Neumann Architecture (SISD); uniprocessor, coprocessor, and multiprocessor systems; SIMD and MIMD machines.

Digital Data Manipulation

Number representation: binary, octal, hexadecimal, and binary coded decimal; integer, fixed point, floating point formats; sign and magnitude representation, two's complement, excess-n; number range and precision; IEEE floating point standard; fixed and floating point arithmetic operations; error codes: parity, Hamming.

Processor Design

Bus architectures: single, double, and triple; critical race problem; register structure: special purpose registers, general purpose registers, flags; instruction execution cycle; function types: load, store, arithmetic, logical, control transfers, use of stacks, procedure entry and exit, input/output; instruction formals, one address, zero address; addressing modes; instruction decoding and implementation, microprogramming; RISC and CISC architectures.

Computer Organization and Control

Data transfer techniques, polling, interrupts, DMA; bus systems (unidirectional, bi-directional, tristate); bus control, handshaking; memory mapped devices, vectored interrupts, and priority levels.

Peripherals and Interfaces

Characteristics and operating principles of peripheral devices; printers, plotters, VDUs , modems, graphic devices; Data acquisition systems, ADC, DAC; interface requirements, programmable interfaces; data communication techniques, serial, parallel, synchronous, asynchronous; standards RS 232 IEEE 488, VME, IEEE 796/ multibus; real-time applications.

Storage Devices and Systems

Principles of storage devices; storage hierarchy , levels of storage; access methods, sequential access, random access; semiconductor memory, dynamic and static momory; on-line storage, magnetic and optical devices; virtual memory.

Computer Networks

Communication networks, LANs, WANs, MANs, Internet, Intranets; topology, speed, and access mechanisms; protocols, ISO – OSI reference model; examples of and features of the physical , data link and network layers of typical networks such as Ethernet, token bus, X. 25; use modems.

System Software

Operating systems; real – time systems, compilers, linkers, interpreters, loaders, diagnostic and debugging tools, and other utilities; user/software/hardware interfaces, functions and features of the interfaces; operating environments, text based, GUI based; network operating systems;

Recommended Texts

1. Zaks R., “An Introduction to Microprocessors,” Sybex Berkeley, USA, B.P B. Publications, New Delhi, India, 1985

2. Sayers I.L. et. Al, “ Principles of Microprocessors,” CRC Press, Inc., 2000 Corporate Blvd., N.W. , Boca Roton, FL 33431 , USA , 1991.

3. Boyce J. C., “ Microprocessor and Microcomputer Basics,” Prentice Hall, Inc., Englewood Cliffs, N. J., 07632 , USA, 1979

4. Holdsworth B., “ Microprocessor Engineering,” Butterworths and Co, Ltd., UK, 1987.

312 MECHANICS OF SOLIDS

Lectures	=	80 Hours

Energy Theorems 08 Hours

Elastic strain energy; normal stress and shear stress.
Strain energy in torsion and in bending.
Helical springs under axial load and axial torque.
Shear deflection of beams.
Principle of virtual work.
Strain energy and complementary energy solutions for deflections:
Castigliano's Theorems.

Thin Plates 04 Hours

Elastic bending of laterally loaded axi-symmertric plates.

Plasticity* 04 Hours

Torsion of shafts: plastic torque.
Plasticity in pressurized thick-walled cylinders.
Plasticity of rotating thin discs.

Theory of Elasticity and Thermo elasticity * 10 Hours

Equilibrium equations : Cartesian coordinates, cylindrical Coordinates.
Strain in terms of : Cartesian coordinates, cylindrical displacement Coordinates.

Compatibility equations : Cartesian coordinates, Cylindrical Coordinates.

Thermal stress analysis :
Thermo elastic stress : strain equations.
Two-dimensional cases : Plane Stress and Plane Strain, applications.

Finite Element Method **08 Hours**

Principle of Finite Element Method:
Equilibrium, strain compatibility, stress-strain relations.
Analysis of spring elements, stiffness, matrix.
Frameworks, local coordinates, and global coordinate systems.
Analysis of continuous bodies - 2D and 3D

Stress Concentration 04 Hours

Yield Criteria: Ductile materials.
Fracture Criteria: Brittle materials
Concepts of stress concentration:
Concentrated loads and contact stresses.
Geometrical discontinuities, Stress Concentration Factor.

Fracture Mechanics 10 Hours

Fracture concepts
Linear Elastic Fracture Mechanics:
Strain energy release rate, Stress Intensity Factor.
Fracture mechanics for ductile materials.

Fatigue 08 Hours

Fatigue failure, forms of stress cycle, test methods.
S-N curve, high-and low-endurance fatigue.
Statistical nature of fatigue.
Micro-mechanisms of fatigue: Initiation and propagation, fracture surface.
Fracture-mechanisms for fatigue, approach to design against fatigue.
Influential factor: mean stress, geometry, environment, and surface condition.
Cumulative damage, Miner's Rule

Creep & Viscoelasticity 08 Hours

Stress- strain –time –temperature response of materials
Creep behavior metals:
- Creep curve, stages of creep, empirical representations of creep behaviour.
- Creep-rupture testing, Larsen-Miller Parameter.
- Creep under multi-axial stresses.
- Manifestation of creep as Stress Relaxation.

Viscoelasticity:
- Linear and non-linear viscoelasticity.
- Creep behaviour of plastics, Isometric and Isochronous curves.
- Designing for creep in plastics, creep rupture of plastics.

Experimental Stress Analysis 08 Hours

Experimental stress analysis techniques.
Electrical resistance strain gauges, rosette analysis.
Strain gauge applications, transducers.

Revision Exercises 08 Hours

- Extension of subject matter covered in Part II – Strength of Materials

Recommended Books

Highly Recommended

1. Mechanics of Engineering Materials, Benham P.P., Crawford R. J. Longman Sc. & Tech., 1988.

2. Mechanics and Materials for Design,Nathan H. Cook,McGraw –Hill., 1985

Also Recommended

3. Advanced Strength & Applied Elasticity, Ugural.. & Fenster…

4. Advanced Solid Mechanics, Lancaster .. & Mitchell…

313 DYNAMICS OF MECHANICAL SYSTEMS

Lectures = 80 Hours

Theory of Lubrication 18 Hours

Distinction between boundary and film lubrication. Reynolds equation in 2D, tilting pad type thrust bearings, Comparison of load capacities and minimum film thicknesses. Journal bearings and externally pressurized bearings.

Vibration 32 Hours

Vibration analysis of multi-body and distributed – mass linear systems.
Multi-rotor torsional systems, geared systems and branched systems.
Vibration of a string. Transverse vibration of beams. Whirling of a single disc on a shaft. Approximate numerical methods – Holzer method and its correction formulae, Rayleigh method, Dunkerley's method, Rayleigh- Ritz method, Matrix method and matrix iteration.

Introduction to other methods of vibration analysis such as Impedance Method, receptance method and Stodola's method

Descriptive analysis of vibration dampers, vibration absorbers, and vibration deturners.

Dynamical Systems 30 Hours

Mathematical modeling of dynamic systems and their representation using Block diagrams and Signal flow graphs. Laplace transformation and transfer functions.

Transient response analysis of first and second order linear systems subjected to impulse, step and ramp inputs.

Determination of absolute stability suing Routh – Hurwitz criterion. System analysis suing Root-Loci.

Frequency response analysis. Polar plots, Nyquist stability criterion, Bode Plots. Determination of Gain margins and Phase margins.

LABORATORY EXPERIMENTS

1.	Design of Flywheel	06 Hours
2.	Harmonic Analysis	06 Hours
3.	Design of a Cam	06 Hours

RECOMMENDED BOOKS

1. Basic Lubrication Theory, Cameron (Longman)

2. Fundamentals of Fluid Film Lubrication, Bernard J. Hamrock (McGraw- Hill, Inc.)

3. Mechanics of Machines – Advanced Theory and Examples, J. H. Hannah & R. C. Stephens (Edward Arnold Publishers Ltd.)
4. Theory of Vibration with applications, William T. Thomson (George Allen & Unwin Ltd. London)

5. Vibration Problems in Engineering, S. Timoshenko, H. H. Young and W. Weaver, Jr. (John Wiley & Sons)
6. Mechanical Vibrations, G.K. Grover (Nem Chand & Bros Roorkee)

7. Dynamics of Physical Systems, Robert A. Cannon, Jr. (McGraw – Hill Book Co.)

8. Control Systems Engineering, Stephen P. Banks (Prentice – Hall International)

314 Applied Thermodynamics

Lectures = 80 Hours

Gas Turbine Cycles 10 Hours

Gas turbine cycles; effect of intercooling, reheating, and heat exchange. Influence of component efficiencies, pressure ratio and maximum cycle temperature on overall performance.

Refrigeration Cycles 10 Hours

Practical vapour compression refrigeration cycles; effect of state of working fluid at compressor inlet and condenser outlet; cascade circuits. Qualitative treatment of simple ammonia –water absorption cycle.

Theory of Mixtures 12 Hours

Mixtures of gases and vapors; reaction between specific and molar properties. Application to condenser and cooling towers. Psychrometry; principles of air conditioning and the elementary analysis of air conditioning plant.

I. C. Engines and Performance Testing 10 Hours

Factors limiting the performance of spark ignition and compression ignition engines. Performance testing; indicator diagrams; Morse Test.

Heat Transfer 38 Hours

Conduction 12 Hours

Steady conduction with plane, cylindrical and spherical isothermal boundaries and with internal heat generation; development of finite difference equations for the solution of steady two dimensional and unsteady one dimensional conduction.

Convection 10 Hours

Surface and overall heat transfer coefficients. Velocity and temperature boundary layers. Natural and forced conventions over flat plates and inside pipes.

Radiation 08 Hours

Heat transfer by radiation. Law of radiant heat transfer for black and gray bodies. Black and gray body radiation for simple configurations.

Combine Modes 08 Hours

Heat transfer from extended surfaces; parallel flow and counter flow heat exchangers. Mean temperature difference.

LABORATORY EXPERIMENTS

I Compulsory Practicals

1. Refrigeration apparatus
2. Trail on Tangy Engine
3. Trial on Cochran boiler
4. Trial on stem turbine
5. Orsat's apparatus
6. Hydraulic simulation of heat transfer

II Optional Practicals

1. Heat pump
2. Forced convection heat transfer apparatus
3. Separating and throttling calorimeter
4. Trail on air compressor
5. Trial on Perkin's engine
6. Field plotter
7. Lagging test

It is recommended to perform at least ten (10) practicals. IESL may select practicals form the optional list.

RECOMMENDED BOOKS

II Applied Thermodynamics

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

2. Basic Engineering Thermodynamics in S. I. Units by Rayner Joel.

3. Thermal Environmental Engineering by J. L. Threlkeld

4. Heat and Mass Transfer by E R G Eckert

5. Heat Transfer by Alan J. Capman

6. The Internal Combustion Engine in theory and Practice Volumes I & 2 by C. F. Taylor

II Fluid Mechanics

1. Fluid Mechanics (Sections 1,2,3,4 & 5) by F M White (McGraw Hill)

2. Fluid Mechanics (Sections 1,2,3,4 & 5) by V L Streeter and E Benjamin Wylie (McGraw Hill – International Student Edition)

3. Fluid Mechanics (Section 1,2,3,4 & 5) by J F Douglas, J M Gasiorek and J A Swaffield (Longman Sciencetific & Technical)

4. Physical Fluid Dynamics (Sections 2 & 6) by D J Tritton (Oxford University Press)

5. Mechanics of Fluid (Sections 1,4,5& 6 by W J Duncan A S Thom and A D Young (Edward Arnold Ltd.)

6. Mechanics of Fluids (Section 1,2,3,5& 6) by B S Massy (Van Nostrand Reinhold Company Ltd.)

315 HIGHWAY & TRAFFIC ENGINEERING

Lectures = 80 Hours

Highway Engineering 40 Hours

Highway Construction Materials 10 Hours

Soils, aggregates and binders-their types, physical properties, testing and evaluation of properties and functions in highway construction.

Highway Construction Methods 12 Hours

Construction of bases, sub-bases, soil stabilization, phalt as concrete and flexible pavement design; investigations, design procedures, specifications construction methods, equipment used, quality control and testing procedures.

Geometric Design of Highways 10 Hours

Introduction to geometric Design, Considerations in the selection of a route for a new road, vertical and horizontal alignment, design of carriageway, maximum axle loads, sidewalks, pedestrian crossings, parking, signs and read markings, turning bays, climbing lanes, bicycle lanes and passing lanes and street lighting.

Investigation of Existing Roads & Maintenance 08 Hours

Quality of riding surface, types of road failures and appropriate maintenance methods, maintenance programs and standards and specifications for road and bridge works.

Traffic Engineering 40 Hours

The Transport Function in Society 02 Hours

Introduction to economic, social and environmental impact of transportation activity.

Traffic Survey techniques and Analysis 06 Hours

Methods of data collection, traffic surveys, determination of sample sizes and survey procedures; analysis of data and statistical tests, survey in transportation and data collection.

Traffic Theory & Applications 08 Hours

Basic traffic theory of flow, speed and density, their inter-relationships, methods of measurement, determination of highway capacity and levels of service and identification of element for geometric design of roads.

Properties of speed, flow and density under deterministic and stochastic conditions and their applications in traffic systems management.

Traffic Control Methods 04 Hours

Traffic restraint measures, turning movement restrictions, uniflow systems.

Intersections Design 10 Hours

Types of intersections and their appropriate used; design of different types of roundabout (traffic circles); design of signalized intersections, types, phases and determination of signal timing.

Traffic Delay Studies 04 Hours

Delays at intersections, delays due to moving or stationary traffic flow obstructions; costing of delays, vehicle operating costs and value of time.

Safety & Accident Analysis 04 Hours

Accident causation and injury prevention, accident reporting, investigation of highly prone categories and black spots, remedial measures and safety education.

Non-Motorized Transport 02 Hours

Pedestrian, Bicycle and Bullock-cart movement; needs separation of fast and slow traffic and safety.

316 ENVIRONMENTAL ENGINEERING

Lectures = 80 Hours

Environmental Microbiology 08 Hours

Discussion of need of microbiology for environmental engineers, types and characteristics of unicellular and multicellular microorganisms, classification of bacteria based on carbon source, energy source and electron donor, and other classifications based on requirement of oxygen, cardinal temperatures etc., types of bacteria significant in Environmental Engineering indicator organisms, enumeration of bacteria-plate counts, multiple tube fermentation technique and membrane filtration technique, significance of other microorganisms in Environmental Engineering.

Water Related Diseases and Principles of Epidemiology 06 Hours

Water borne, water washed, water based and water related insect vector caused diseases and their control, the chain of infection and its links (causative agent, portal of exit, route of transmission, portal of entry and susceptible host), common diseases in Sri Lanka, their causative agents, signs and symptoms, incubation periods, carriers and methods of control.

Water Treatment 30 Hours

Principles and design concepts of the following conventional water treatment unit operations-Aeration, Sedimentation, Coagulation, Flocculation, Filtration, Disinfection, Stabilization.

Miscellaneous water treatment operations – softening, iron removal, desalinization, removal of organic, contaminants.

Rural water supplies – special considerations in rural water supplies.

Waste Water Treatment 20 Hours

Kinetics of biological wastewater treatment

Design and operational principles of conventional biological waste water treatment (aerobic and anaerobic)

Design and operational principles of physico-chemical treatment of wastewater.

Special considerations in treatment of domestic and industrial waste water.

Rural sanitation and simple waste treatment methods.

Environmental Pollution Control 16 Hours

Water pollution – self-purification of streams, DO sag equation, water quality standards, toxic materials, ground water contamination, methods of control of surface and ground water pollution.

Air Pollution – Stationary and mobile sources of air pollution, primary and secondary pollutants, air quality standards, local, regional and global effects of air pollution, health aspects and control measures.

Noise and vibration - noise levels and measurement of noise, standards, effects and reduction methods of noise and vibration.

Solid and Hazardous Waste Disposal - Quantities and characteristics of solid waste, storage, collection, transport, and disposal methods of solid waste, definition of hazardous waste, the ‘cradle to grave’ approach of handling hazardous waste.

LABORATORY EXPERIMENTS

1. Determination of characteristics of waste water-BOD, COD and solids (Total, Suspended, volatile suspended, settleable etc)

2. Jar Test - determination of coagulant dose and variation of coagulation dose with characteristics of the water.

3. Variation of water quality and head in different units in a water treatment plant. (done on a field visit)

4. Sludge Characteristics

5. Operational parameters of Activated Sludge treatment of waste water (done on a field visit)

RECOMMENDED BOOKS

1. Principles of Water Quality Control - Fourth edition (1992) or latest edition – T H Y Tebbutt, Pergamon Press
2. Physicochemical Processes: for water Quality Control – Walter J Weber, John Wiley and Sons, New York.
3. Environmental Health Engineering in the Topics : An Introductory Text – Sandy Cairncross and Richard G Feachem, John Wiley and Sons, New York.
4. Water Treatment Plant Design for the Practicing Engineer – Robert L Sanks – Ann Arbor Seience.
5. Water and Waste Water Engineering, Vol II – G M Gair, J C Geyer and D A Okun, Wiley, New York,
6. Microbiology for Sanitary Engineers - R E McKinney, McGraw Hill, New York.
7. Microbiology for Environmental and Public Health Engineers- (1998) Robert M Steritt and John W Lester, E & F N Spon, London.
8. Chemistry for Sanitary Engineers - C N Sawyer and P L McCarty, McGraw Hill
9. Water and Wastewater Technology – Mark J Hammer, John Wiley and Sons.
10. Wastewater Engineering- Treatment, Disposal, Reuse-3rd Edition – Metcalf & Eddy McGraw Hill, New York.
11. Introduction to Environmental Engineering- M L Davis and D A Cornwall McGraw Hill, Hew York.
12. Biological Wastewater Treatment Systems: Theory and Operation – N J Horan , John Wiley & Son, New York.
13. Air Pollution – A J Stem, Academic Press, USA
14. Solid Waste Management in Developing Countries – A D Bhide and B B Sundaresan, Indian National Scientific Documentation Centre, New Delhi

317 IRRIGATION AND WATER POWER ENGINEERING

Lectures = 80 Hours

Irrigation and Water Power Principles 20 Hours

Soil – Plant – Water Relationships, Soil Moisture Storage, Water Available to the Plant, Field Capacity, Permanent Wilting Point, Infiltration, Reference Crop Evapotranspiration, Crop Growth Stages, Crop Coefficient, Crop Evapotranspiration, Effective Rainfall, Water Balance Concept, Efficiency Concepts.

Power Potential of a Stream, Catchment Yield, Gross and Net Head, Efficiency Concept, Units of Power, Firm and Surplus Power.

Irrigation Practices and Water Management 14 Hours

Surface Irrigation, Border and Furrow Irrigation, Sprinkler and lift Irrigation, Sub Surface Irrigation, Wetting Patterns, Field Irrigation Requirement, Object of Water Management, Methods of Water Issue, Preparation of Irrigation Schedules, Reservoir Operation.

Planning and Design of Irrigation Systems 10 Hours

Micro Hydro-mini Hydro-ordinary Hydro-Low Head-High Head-Run of River-Storage or pumped Storage Systems, Impulse and Reaction Turbines: Francis, Kaplan and Pelton Wheel-Efficiency-Cavitation-Operational and Specific Speeds, Diversion Structure, Penstock, Power House, Distribution, Surge Tanks, Tailrace, Valley-Dam Power Plant and Under Ground Power Station Layouts.

Irrigation and Water Power Project Appraisal 20 Hours

Multipurpose Projects, Cost-benefit Analysis, Method of Discounting, Time Value of Money, Financial and Economic Costs and Benefits, Cash Flow Diagrams and Interest Computations, Project Feasibility, Environmental considerations and Valuation.

RECOMMENDED TEXTS

Irrigation Development Planning, Rydzewski J R John Wiley & Sons

Irrigation: Design and Practice, Bruce Withers & Stanley Vipond, Batsford Academic & Educational Limited London.

Water-Resources Engineering, Linslay at all, McGaw- Hile Inc

Water-Resources and Agricultural Development in the Tropics, Chris Barroow, Longman Scientific & Technical

Irrigation Engineering, J G Dahigaonkar, Wheeler, India

Elementary Irrigation Engineering, S K Garg & Garg, Khanna Publishers

Irrigation Theory and Practice, A M Mocheal, Vikas Publishing, India

Hydraulics and its Application, A H Gibson, Longmans Green and Company

Applied Hydraulics in Engineering, H M Morris & J M Wiggert, John Wiley & Sons

318 BUILDING SERVICES ENGINEERING

Lectures	=	80 Hours

Introduction

Building Services Engineering is concerned with the human, scientific, technical and economic aspects of design, construction and maintenance of all engineering associated with the built environment, other than its structure, as well as with similar elements associated with certain industrial processes.

BUILDING DRAINAGE AND WATER SYSTEMS

Drainage Systems 14 Hours

Design of sanitary and storm water drainage systems for buildings and a knowledge of the Construction and Maintenance requirements of such systems – design loadings and components in a system, piping layouts, piping materials, sand interceptors, oil and grease separators, sewage backflow preventing devices, cleanouts, interception of volatile fluids, piping sleeves, vent systems and local regulations.

Basic knowledge in design, operation and maintenance requirements of waste water system for laundry machines and parking area drainage.

Detail knowledge in carrying out site inspections and tests on drainage systems and their maintenance procedures.

Plumbing Fixtures: Demand and dischange rates of plumbing fixtures, prohibited fixtures and connection, special fixtures, minimum facilities, capacities of plumbing stacks in buildings and sloping drains.

Basic knowledge in cost estimating of sanitary and storm water drainage systems.

Water Systems 12 Hours

Identification of water requirements for various types of buildings. Design of water supply system in the building – quality standards, design loads, pipe layouts, and materials, colour codes, air-gaps, backflow preventers, drinking – fountain standards, pressure regulators and calculation of capacities of pumps.

Basic knowledge in installation methods and maintenance requirements of potable water systems.

Detail knowledge in carrying out site inspections and tests including disinfection of piping and maintenance procedures.

Basic knowledge in cost estimating of water supply systems.

Mechanical Services Systems

Fire Protection Systems 12 Hours

Knowledge of the principal criteria for assessing the fire properties of building construction materials. These properties are : Combustibility, ignitability, fire propagation and rate of surface spread of flame. Discuss concept of fire load density. Outline the principles of means of escape in case of fire and also the provision of access for fire appliances to buildings for fire fighting purposes.

Outline the use, siting, and maintenance of portable fire extinguishers, and extinguishing equipment.

Explain the principle requirements of fire safety, fire precautionary and fire legislation and their attendance code of practice, rules and regulations.

Outline the design features, commissioning, operations and maintenance of the fixed installations – sprinkler systems, hose reels and fire detection systems.

Basic knowledge in cost estimating of fire protection and detection systems.

Heating Systems 05 Hours

Types of boiler plant and installation methods. Assessment of fuel storage requirements. Design of a central, multiple boiler installation and control of heating circuits. Analysis of part-load operation and system efficiency. Water Treatment requirements.

Basic knowledge in cost estimating of heating systems.

Ventilation Systems 05 Hours

Determination of supply and extract volumes, design air distribution circuits and network analysis. Prediction of room air distribution, location of supply and extract grilles and diffusers. Fan selection and characteristics. Air filtration, standards and methods of filter testing, applicability of test data. Sound control and vibration isolation. Ventilation of hazardous environments, extract hood and fume cupboard design.
Basic knowledge in cost estimating of ventilation systems.

Air Conditioning Systems 09 Hours

Analysis of air conditioning cycles, determination of room, zone, and plant loads. Load charts for plant operation and control strategy.

Design philosophy and principles of air conditioning systems, single duct, dual duct, variable air volume, fan coil and induction systems. Ventilation and Heat Pump recovery systems, applications, operations, control, and economics. Selection of heating, cooling and dehumidifying coils, capacity control, part load performance. Dynamic response of the building and plant under transient load conditions.

Basic knowledge in cost estimating of air conditioning systems.

Refrigeration Systems 04 Hours

Performance characteristics of reciprocating, centrifugal and screw compressors, condensers and evaporators. Multiple chiller plant, series and parallel operation and control.

Basic knowledge in cost estimating of refrigeration systems.

Electrical Services and Lighting Systems

Electrical Services 09 Hours

The design and critical analysis of distribution systems suitable for various building types.

Cable types and their application and sizing within and around a building. Protection against overload, short-circuit and indirect contact. Fault condition, prediction of maximum short – circuit and minimum earth – fault currents. Current protective devices for short – circuit and overload protection within buildings. Use of back-up protection.

Private generation, use of alternative and stand-by supplies.

Basic knowledge in cost estimating of electrical systems.

Lighting System 05 Hours

Lamps and characteristics, the selection of luminaries by performance and economic parameters for a given environment. The design of lighting system for specialized application, eg. Hazardous areas, hospitals, museums, art galleries, etc. Integrated ceiling systems. Emergency and escape lighting.

Basic knowledge in cost estimating of lighting systems.

Specialized Service Systems 05 Hours

Basic knowledge in design, installation, commissioning & operation of lifts, escalators, Building maintenance management systems, telephone systems, public address systems, closed circuit T V systems, and lightning protection systems.

Basic knowledge in cost estimating of specialized service systems.

RECOMMENDED READING LIST

1. A C Panchdhari, " Water Supply and Sanitary Installations – (within buildings) , Design, construction and maintenance", Wiley Eastern Ltd, 1993

2. Louis Blendermann, " Design of Pluming and Drainage Systems", Industrial Press Inc., 2nd Edition, 1963

3. A L Tonwsend, " Plumbing 1 & 2", Hutchinson, 2nd edition ,1977

4. IEE Wiring Regulations 16th Edition "Requirements for Electrical Installations" BS 771 : 1992

5. CIBSE Guide

6. Codes of Practice for Protection of structures against lightning.

7. Electrical Installation Technology – Neidle

8. Newnes Electrical Pocket Book - Edited by E A Reeves

9. Modern Refrigeration and Air-conditioning – A D Althouse, C H Turngurist and A F Bracciano; Goodheart – Wilcox Company Inc.

10. Refrigeration and Air-conditioning – P L Ballaney; Khanna Publishers.

319 HIGH VOLTAGE ENGINEERING

Lectures = 80 Hours

Breakdown of Gaseous, Liquid and Solid Insulation 10 Hours

Ionization processes, Breakdown of gases: electron avalanche mechanism Townsend current growth, Paschen's Law, Streamer Theory of breakdown, Time lags of spark breakdown.

Coronal Discharges, Mechanism of corona formation, corona loss.

Breakdown in Liquids: Breakdown due to gaseous inclusion , liquid globules, solid particles.

Breakdown of solid insulating materials: Intrinsic breakdown, electromechanical breakdown, breakdown due to internal discharges, surface breakdown, thermal breakdown, electro-chemical breakdown, chemical deterioration.

High Voltage Transient Analysis 18 Hours

Lightning stroke mechanism: frequency of occurrence of flashes. Transmission lines: Shielding by earth wires, shielding angle, area of attraction to lightning. Direct strokes to phase conductor, tower, earth wire. Indirect strokes.
Surges on transmission lines: Surge impedance and velocity of propagation. Energy stored in surge. Reflection of traveling waves at a junction, bewley lattice diagram, reflection and transmission at a T – junction. Transform Methods of solving transients.

High Voltage Cables 10 Hours

Classification of high voltage cables. Power loss in the cable: dielectric loss, conductor loss, sheath loss, inters heath loss; Cross-bonding of cables. Insulation resistance and capacitance of single phase and three phase cables. Copper space factor.

Di- electric stress in single core cable: Cable grading for uniform stress distribution, capacitance grading, intersheath grading.

Thermal design of cables: current rating. Thermal resistance of single-core cables, three-core cables, protective coverings, ground around cable, cables exposed to air.

High voltage bushings: Simple cylindrical bushing, condenser bushing.

Measurement of High Voltage 12 Hours

Direct measurement of High Voltages: Electrostatic voltmeters, sphere gaps, Transformer and potential divider methods of measurement: Transformer ratio method, Resistive potential divider, capacitive klydonograph, peak reading voltmeters, oscilloscope for measurement of fast transients.

Measurement of capacitance and loss tangent: High voltage Schering bridge, dielectric loss measurement using oscilloscope, detection of internal discharges, measurement of dielectric constant and dissipation factor of a liquid dielectric using resonance.

High Voltage Generation for testing 12 Hours

Generation of High Alternation Voltages: cascade arrangement of transformers, resonant transformers.

Generation of high direct voltage: rectifier circuits, voltage multiplier circuits. Electrostatic generators: van de Graeff generator, sames generator.

High voltage impulse generators: Double exponential waveform, calculation of coefficients a and b from resistance and capacitance values, definition of wavefront and wavetail times of practical waveforms.

Uncontrolled operation, controlled operation of impulse generator, Trigatron gap. Multi-stage impulse generators. Generation of chopped impulse waveforms.

High Voltage Testing

General tests carried out on high voltage equipment: sustained low-frequency tests, high voltage direct current tests, surge tests. Type tests, sample tests, routine tests.
Testing of solid dielectric materials: determination of dielectric strength.

Insulation co-ordination in electric power systems 10 Hours

Conventional method of insulation coordination
Statistical method of insulation coordination: Evaluation of risk factor length of overhead shielding wire, modification of wave shape by corona

Surge protection: Spark gaps for surge protection, expulsion tube lightning arrestor, surge diverters; selection of surge diverters, separation limit for lightning arrestors.

LABORATORY EXPERIMENTS

1. High Voltage impulse generator
2. Breakdown characteristics of gaps
3. Corona characteristics
4. Stress analysis using the electrolytic tank

RECOMMENDED BOOKS

1. High Voltage Engineering by J R Lucas, University of Moratuwa, 1995
2. High Voltage Engineering by Ms. Naidu and V Kamaraju, Tata McGraw- Hill, 1990
3. High Voltage Technology by L L Alston, Oxford University Press, 1967
4. High Voltage Engineering by E Kuffel and M Abdullah, Pergamon Press, 1970
5. Extra High voltage AC Transmission Engineering by R D Begamudre. Wiley Eastern Ltd, 1990
6. The Protection of Transmission Systems against Lightning by W W Lewis, Dover Publications, 1965

320 POWER ELECTRONICS AND APPLICATIONS

Lectures = 80 Hours

Devices 18 Hours

Heavy current high voltage devices: characteristics of diodes, thyristors, triacs, gate turn off thyristors, power hipolar and MOS transistors, insulated gate bipolar transistors, other MOS-bipolar hybrid devices.

Protection: over current and over voltage protection, di/dt and dv/dt limiting, switching aid (snubber) networks with and without energy recovery, lossless snubbers, temperature effects and cooling, thermal resistance and impedance, heat sink designs.

Drive circuits: power and s peed of drive circuit, isolation with optical and transformer methods (including pulse transformers), power integrated circuits.

AC to DC Converters 16 Hours

Phase controlled converters: single and three phase bridge converters, half and fully controlled types, characteristics with passive and active (motor) loads, inversion mode, continuous and discontinuous current, commutation overlap, 12 and 24 pulse circuits, transformer connection and ratings, influence on supply, harmonics.

Control of converters; linear firing angle control, cosine-wave crossing method of control, phase-locked –loop control.

PWM rectifiers: active line current shaping, single, and three phase types.

DC to DC Converters 10 Hours

PWM Converters: buck, boost, buck-boost and cuk converters, single, two and four quadrant operation, isolation and multiple outputs.

Resonant link converters: resonant converters, half and full bridge types, zero-voltage and zero- current switching, series, parallel, quasi and multi resonance converters.

DC to AC Converters 20 Hours

Voltage fed inverters: square wave single and three phase inverters, self and forced commutated types, operation with 180 and 120 conduction, performance with inductive loads, harmonics, constant volts/hertz operation.

Current fed inverters: load and forced commutated (auto sequential) inverters.

PWM Inverters : sinusoidal PWM with natural and uniform sampling, single and three phase operation, harmonic elimination PWM, current control PWM with hysteresis and predictive (space vector) control, PWM with current fed inverters, PWM Inverter- PWM rectifier double converter systems (voltage fed and current fed types), PWM direct frequency changes and cycloconverters

Resonant inverters: single and three phase resonant inverters, resonant dc-link and resonant as-link types, voltage fed and current fed operations.

Application 16 Hours

Specialized applications: static Var and harmonic compensators, high frequency induction heating, electroplating, high frequency fluorescent lighting, uninterruptible power supplies (UPS), electrical machines control, as voltage regulators, electric locomotives, power line filters etc.

Application specific integrated circuits (ASICS)

RECOMMENDED BOOKS

1. Power electronic control of AC motors
Pergamon Press
J M D Murphy & F G Turnbull

2. Power Electronics and AC drives
Prentice Hall
B K Bose

3. Power Electronics
Devices, Drives and Applications
MacMillan
B W Williams

4. Power Electronics
Converters, applications, and Design
John Wiley & Sons
Hed Mohan, Tore M Undeland, William P Robbins

321 PHYSICAL ELECTRONICS

Lectures = 80 Hours

Physics of Materials 20 Hours

Wave-Particle duality of light; wave-particle duality of matter.
Time independent schrodinger wave equation and its application to H-atom; quantum numbers.
Electron in box and the free electron model of a metal: Somerfeld model of a metal.
Electron in a periodic potential well; kronig-penny model of a crystalline sllllolid;
Band theory of solids; distinction of conductor; semiconductors and insulators.
Density of states and the probability of occupation of a conductor according to Fermi-Direc statistics;
Fermi level and work function of a metal.

Semiconductors and semiconductor devices 20 Hours

Electrons and holes in semiconductor; effective mass of electrons and holes
Density of states and the probability of occupation of electrons in a semiconductor; carrier densities;
Fermi level of intrinsic and extrinsic semiconductors.
p-n junction in equilibrium and non-equilibrium; diffusion mechanism;
Diffusion and depletion layer capacitance at the junction; conduction in a p-n junction diode;
Breakdown mechanisms of a p-n junction; rectifier diodes and zener diodes.
Small signal ac equivalent circuit of the p-n junction diode and switching properties.
Diode as a variable resistance and a variable capacitance;
Detector & mixer diodes, varactor diode, tunnel diode, backward diode, Gunn device, IMPATT diode.
Metal- semiconductor junctions; schottky barrier diode.

Bipolar transistor and its small signal ac equivalent circuit; hybrid model and the high frequency performance of the transistor; switching properties of the transistor.
Field effect transistor, MOSFET, and MESFET.
Charge coupled devices, SCR, DIAC, TRIAC and UJT.

Microelectronics 10 Hours

Fabrication of discrete devices and Integrated circuits.
Planar technology; Epitaxy; Oxidation, Diffusion and Ion Implantation; VLSI

Optoelectronic Devices 15 Hours

Principles of laser action; solid-state lasers, gas lasers; semiconductor lasers.
Optical emitters and sensors: LED, LD, PIN-PD, APD, Photo cells.
Solar cells and solar panels.
LCD displays ; Optical fibres.

Electron tubes

Electron tube in the CRO and TV.
Electron tubes in a klystron amplifier, reflex klystron, traveling wave tube, magnetron, and the cross field amplifier.

Noise in semiconductors 05 Hours

Thermal noise, shot noise , flicker noise, recombination noise, noise figure, noise temperature.

LABORATORY EXPERIMENTS

1. To examine the high frequency performance of a common emitter amplifier by computer simulation using PSPICE.
2. To obtain the transfer characteristics and the transient response of a CMOS inverter with inverter load by computer simulation.
3. To obtain the transfer characteristics and the transient response of standard TTL NAND gate with a load by computer simulation.
4. To observe the transient response of a CMOS NAND with a inverter load and a track capacitance y computer simulation.

Recommended Text:

J Seymour, " Electronic Devices and Components", Longman Group UK Lts, 1988

Supplementary reading:

1. Adir Bar-Lev, " Semiconductors and Electronics Devices", Prentice – Hall International, Inc., 1984
2. Morgan D V and Board K, "Semiconductor Micro technology", John Wiley & Sons,1983

Note on the Objective of the drafted syllabus

The course provides an introduction to the physical principles underlying the operation of present-day electron devices and components.

The approach is to initially formulate a simple theory for the operation of the device, then an equivalent circuit that depends on the external factors, as voltage, current, temperature and the material properties. The device advantages and limitations are deduced and finally the common applications discussed.

322 OPERATIONAL RESEARCH

Lectures = 80 Hours

Introduction to Operational Research 04 Hours

Philosophy of the Management Science/operational Research; Quantitative approach to management decision making; Development of scientific management from Industrial Engineering to Management Science/Operational Research : Operational research today and the relationship between the OR practitioner and the Manager; Applications of Operational Research; Systems approach in Operational Research; Classification of mathematical models and types of models; computers and information systems.

Principles of Decision Analysis 06 Hours

Decision Criteria; Basic relationships of probability; conditional probability; decision trees; bayes' theorem; utility as a decision criteria; Replacement Analysis (It is expected that basic knowledge on probability is given in Mathematics subject)

Linear Programming 14 Hours

Formulation of a mathematical model for the central problem; graphical method; simplex algorithm for solving the problem; sensitivity analysis, B-ranging, C- ranging; Interpretation of Primal and Dual in linear programming problems; some technical issues in linear programming such as Infeasibility, Unbounded ness, Redundancy, Alternative optimum, and Degeneracy; Linear programming real-world applications; computer application.

Transportation and Assignment Techniques 08 Hours

Transportation method as a special case of linear programming problems; Matrix formation for the central problem; Northwest corner rule; Lowest cost cell rule; Modi method; degeneracy; real-world application; computer applications; assignment problem.

Inventory control 12 Hours

Formulation of the central problem; economic order quantity (EOQ); Graphical presentation and formulae for EOQ; Finite production rate; re-ordering; quantity discounts; stock outs (back-orders) ; probabilistic stock system; variability of demand and lead time; cyclical review; re-order level; re-order point systems.

Queuing Theory

Simple queuing systems, queuing objectives and cost behavior, layout of queuing systems; Poisson distributed arrivals; exponentially distributed service times; queuing systems for finite queues; limitations of queuing theory; simulation of queues.

Simulation 08 Hours

Need for simulation; simulation in practice; types of simulation; probabilistic simulation; Monte Carlo method time dependent systems; event dependent systems; applications in Inventory Control and Queuing systems; computer applications.

Network Analysis 14 Hours

Basic network terminology and definitions of events, activities, and duration; rules for constructing networks; identity dummy and logic dummy activities; time analysis; earliest event time and latest event time of an event; earliest start time, latest start time, earliest finish time and latest finish time of an activity; total float, free float and independent float; critical path method (CPM) and programme evaluation review technique (PERT) ; cost scheduling; network compression and minimum cost and /or time paths; resource scheduling, resource leveling and smoothing; computers in project planning; precedence networks.

Course Works (Introduction and Explanation) 06 Hours

Course work I (25 marks)

The students will be asked to solve a real-world linear programming problem (preferably using a computer application) and interpret the solutions.

Course work 2 (25 Marks)

The students will be asked to solve a real-world inventory control problem using the simulation technique and interpret the solution.

Course work 3 (50 marks)

The students will be asked to identify the activities and construct a network for a real world project; identify the critical path, allocate resources, undertake leveling and smoothing; and prepare progress charts.

RECOMMENDED BOOKS

1. Quantitative Approaches to Management-Seventh edition; by Richard I Levin, David S Rubin, Joel P Stinson, and Everette E Gardner. McGraw – Hill, New York.*
2. Statistics for Business and Economics-fourth edition; by David R Anderson, Dennis J Sweeney, and Thomas A Williams. West Publishing Company, New York.*
3. Operational Research; by S S Cohen. Edward Arnold, London.*
4. Quantitative Techniques; An Instructional Manual by T Lucey. D P Publications, London ELBS publication: ISBN 1 905435893 *
5. Operations Research; by B S Goel and S K Mittal. Rragati Prakashan, Meerut, India.
6. Probability and Statistics for Engineering and Sciences – Third Edition; by Jay L Devore. Brroks /cole Publishing Company, California.
7. Systems Analysis; by John Bingham and Grath Davies. Macmillan, London.

* Highly recommended

323 CONTROL SYSTEMS ENGINEERING

lectures 80 Hours

Eligibility test

An eligibility test should be administered to all students who are planning to offer this optional subject for Part III. The test should cover topics the students should have learnt in Part I and II. These topics are essential to follow the lecture series on control systems engineering. Since only 132 hours have been allocated for this subject these topics will not be again taught in depth.

Topics to be covered by the eligibility test

Differential Equations

Classification of differential equations, solution of linear differential equations with constant coefficients, particular integral, complementary solution, homogeneous differential equations,

Laplace transform (LT)

Definition, properties of LT, LT of simple functions, Inverse laplace transform, partial fractions.

Fourier algebra

Manipulation of complex numbers, mapping, partial fractions involving complex numbers, representation of a periodic function by a complex number determination of magnitude and phase of a ratio of two complex polynomials.

Nonlinear systems

Solution of second order differential equations using phase plane method, nonlinearities due to hysteresis, backlash, saturation

Property Measurement.

Use of strain gauges (for mechanical stream) use of thermocouples, thermistors (for electrical and electronic streams)

Only those who obtain an A (over 70%) for the prerequisite test should be allowed to register for the subject.

Section A - Linear Control Systems (32) Hours

A 1 Introduction 02 Hours

Simple properties of open and closed – loop systems. Terminology, Qualitative description of simple control systems. Concepts of accuracy, precision, stability, and sensitivity.

A2 Transient and Steady State Analysis 18 Hours

Dynamics of simple linear devices and systems, covering differential equations for basic electrical, mechanical, thermal , fluidic elements such as inductor, capacitor, mass, viscous friction, thermal storage element, fluid storage; Representation of dynamic systems using higher-order differential equations; Definition of laplace transform, properties useful for control engineers, unit impulse, unit step and unit ramp functions, free and forced response, transfer function, transient and steady state responses, position error constant, velocity error constant, transfer function of simple engineering systems such a R _C circuits, unity and nonunity feedback systems, overall transfer function, block diagram representation of systems, rules for manipulating block diagrams. Characteristic equation, pole-zero representation, closed-loop time domain specifications, Routh-Herwitz criterion.

A3 Frequency Domain Analysis 12 Hours

Basis for frequency domain analysis, steady state response of linear systems to sinusoidal inputs and general periodic inputs. Output response of nonunity feedback systems to sinusoidal inputs, Nyquist stability criterion, gain and phase margin, bode diagrams, Nichol's chart, series compensation using phase –lead compensators.

Section B - State vector Equations and Nonlinear systems 34 Hours

B 1. State - Variable Analysis for single-input single-output (SISO) systems 08 Hours

Representation of higher order constant coefficient differential equations for SISO systems using a set of first order differential equations, has variable canonical form, characteristic equation and eigenvalues, transfer function, pole – zero cancellation.

B 2. State- Variable Analysis for general systems 16 Hours

General vector-matrix differential equations for systems, classification of systems by (i) system order (ii) number of inputs (iii) number of outputs (iv) time dependence or independence (V) analog or discrete (vi) linear or nonlinear (vii) homogeneous or non
Homogeneous, equilibrium points, linearization of systems about a given operating point.

Section C - Nonlinear Systems, Discrete Systems, and Process control 24 Hours

C 1. Nonlinear Control Systems 06 hours

Comparison of linear and nonlinear control systems, mathematical models for (i) ideal relay, (ii) deadband, (iii) backlash, (iv) nonlinear springs, (v) hysteresis and (vi) friction, linearization around operating point, phase-plane method, describing function, limit cycle oscillations, liapunov method, use of explicit Euler and classical fourth-order Runge-Kutta method to solve nonlinear systems.

C 2. Discrete Systems

Difference equations, z-transforms, system transfer function of SISO systems, stability with reference to the location of poles in the Z plane (state –space model for discrete systems, discretization of continuous systems not included), samplers in analog control systems, pulse transfer function, zero-order hold, analysis of analog feedback systems with one sampler (discrete , controllers no included),

C 3. Transducers and Actuators 06 hours

Transducer performance and specifications, transducers for the measurement o linear and angular displacement, force, velocity and acceleration, pressure difference, temperature detector (RTD), thermal and transport lag, use of strain gauges.

Various types of actuators, representation of actuator dynamics using transfer function, conversion of actuator driving signals from electrical to pneumatic actuators with digital inputs and digital outputs.

C4. Programmable Logic Controllers PLC

Introduction, specifications of PLC's programming hardware (Hand-held) terminal and computer) , software for programming – matrix programming, statement list (STL) and ladder diagram (LDR) programming, entities inside PLC such as inputs, outputs, pulse timers, on-timers, delay-off timers, counters, flags, practical training on LDR programming of a process involving a maximum of three inputs, three outputs, one timer, one flag and not more than five rungs.

Summary: Section A – linear control systems - 32 hours
(A1 2) + (A2 12)
Section B – State vector Equations & NL - 24 hours

(B1 8) + (B 2 16)
Section C - NL systems discrete systems - 24 hours
(C1 6) + (C2 6) (C3 6) + (C4 6)

Total = 80 Hours

Note * The times given are for a general guidance only and are approximate

Practical List

Three practicals to be done at the control-engineering laboratory at University of Moratuwa

1. Study of a first-order system. Determination control engineering concepts of first-order system by an experiment (3 hours)
2. Manufacture of a load cell using strain gauges and a thin –walled cylinder. Students will be provided with strain gauges, thin-walled cylinder, adhesive, wires and soldering iron. Students should make the load cell. (3 hours) . If there is sufficient time left testing of the load cell could be included.

3. Programming of PLC. Students will be required to write the LDR Program for a typical industrial process needing PLC control. The programme will be downloaded from computer to the PLC. The Program in the PLC should be then simulated by artificially activating inputs. (3 hours)

Note: The Control engineering laboratory can accommodate 12 students for on 3- hours session.

ASSESSMENT PATTERN

I Qualifying Test

A Qualifying MCQ type exam should be given by the lecturer I charge at the end of the lecture series. This test could of 2 hours duration consisting of 100 short questions on fundamentals of control systems engineering.

Those who pass this test will be eligible for the 3-hour final examination.

II 3 hour final examination

The question paper will contain 3 sections with 3 questions each. The question paper may be prepared in the form of "book" with enough blank space between questions. Candidates can write the answers in the space provided. (This will make marking examiners work easier).

Candidates should answer 5 questions selecting not more than two from each section. Programmable calculators (not the ones which can sore formulae in symbol form) will be allowed so that students can do repetitive calculations quicker.

References

Students are strongly urged to have a personal copy of book Number I given below.

1. Automatic control y S N Verma, Khanna Publishers Delhi
2. Automatic control engineering by francis H Raven, McGraw –Hill book Co.
3. FESTO Programming manual.

324 **MACHINE DESIGN**

Lectures = 60 Hours

1. Introduction to Machine Design and its methodology 04 hours

Design objectives
Stages in Machine Design
Role of the computers in Machine Design and introduction computer Aided Design

2. Revision on tolerances, limits and fits 02 hours

3. Revision of failure theories, fatigue, reliability, surface damage etc. and their I importance in machine design 05 Hours

4. Mechanical Power Transmission
Shaft Design -5 hours

Forces on shafts applied from betls and gears

Shaft design based on strength

Shaft design based on rigidity

Shaft design based on critical speed (rotating shaft dynamics)

Design of Belt Drives 03 Hours

Different types of belt drives, belts and pulleys, their applications.

Analytical method and use of ISO/SLSI standards

Keys, Pins, splines and Various other Mechanical Elements

Associated in Power Transmission 02 hours

Rolling Bearings 05 hours

Selection of bearings

Mounting of bearings

Sliding Bearings 04 Hours

Different types of sliding bearings and their applications

Selection of sliding bearings

4. Friction Drives 05 hours
Power screws

Clutches
Brakes
Others

5. Introduction to Hydrodynamics 02 Hours

Fluid couplings
Torque converters

7. Joint or Fasteners 10 hours

Bolt tightening and initial torque
Bolted joints
Welded joints
Riveted joints
Bonding

8. Design features of spur gears, helical gears, bevel gears and worm gear wheel. (strength , surface wear and dynamic load considerations), other factors attribute to failure of gears
06 Hours

9. Design of Helical Gears 03 hours

10. Design of Bevel Gears 02 hours

11. Design of worm and wheel 02 hours

Note

- Whatever possible it is necessary to use International Standards, Manufacturers, Catalogues, Design Hand Books, etc, so that the student would appreciate the use of such materials in their work.
- Quote relevant practical examples wherever necessary so that the student may understand the principles and concepts by relating them to real world applications.

- It is expected to revise under I and 3 above certain, topics which the student had previously covered in other subjects learned in Part I

- It is important the student be given sufficient opportunities to develop analytical skills through eight assignments (CLASS ROOM DESIGN EXERCISES) each of four hours duration. Such EXERCISES are listed separately. Some assignments are to be arranged as home based and some others both home and class room based. The number of hours to be spent at home in such home based and some others both home and class room based. The number of hours to be spent at home in such home based exercises are not considered as a part of the 32 hours to be spent in the classroom. Also it is expected that the student will apply his knowledge in several topics learned previously through these exercises so that the lecturer is not required to devote much of the time in revising such topics but devote time economically in the new topics.

RECOMMENDED BOOKS

1. Machine Design Theory and Practice by Aaron D Deutschman, Walter J Michels and Charles E Wilson
2. Fundamentals of Machine Component Design by Robert R Juvinell
3. Computer Aided Machines Design by Andrew D Dimarogonas
4. Machine Designs by P C Sharma and D K Aggarwal
5. Standard Handbook of Machine Design by Joseph E Shigley, Charles R Mischke
6. Machine Design by M Movnin and D Goltziker

1,2,3, and 5 are considered to be as highly recommended texts. In addition the students are advised to refer to relevant Hand Book in Mechanical Engineering Design /Machine Design.

LIST OF ASSIGNMENTS

	Hours to be Spent		
	Classroom		Home
1. On application of limits and fits and tolerances	04	-	
2. Design of shafts: Incorporating static and fatigue Failures, design for safety using Strength, deflection (both lateral And torsional) and critical speed Concepts.	04	06	
3. On selection of a belt drive for a given power transmission system	04	-	
4. On selection and mounting of Rolling bearings for a given application	04		04
5. On selection of sliding bearing	04	02	
6. On design of a power screw for a given application	04	04	
7. Exercises a few selected joints	02	06	
8. Design of gears for a selected power transmission Application	04	04	
9. Integrated design: A suitable design exercise Incorporating several mechanical Elements studied previously in the Subject . This should cover features Such a strength, production, Maintenance, cost , etc.	02		08

- Compulsory assignment

Five other to e selected from 1 to 9 above of the list

325 MANUFACTURING SYSTEMS ENGINEERING

Lectures	=	80 hours

Course Objective :

The subject deals with the design; installation, operation and improvement if integrated systems of people and machines for the purpose of manufacturing conversion of essential input resources to marketable products. The discussion of application of computer microprocessor and information technology where appropriate is implicit in the syllabus.

Analysis of Manufacturing Systems 08 hours

Classification of Manufacturing systems based on Market goals, objectives, measurement of system performance, static and dynamic characteristics of systems; stability and rate of response, simulation modeling.

Planning & Organizing for Manufacture 10 hours

Long range planning decisions; product design, selection of equipment and processes, Job design, location of system facility layout, materials handling systems, safety and environmental considerations.
04 hours

Organization for manufacture: Organizational structures, line and staff, matrix, management functions, communication, co-ordination, decision making. 06 hours

Forecasting: qualitative methods, technological forecasting, time-series methods move in averages, exponential smoothing. 10 hours

Investment Analysis: Project appraisal, capital budgeting, and cash flow analysis, plant replacement analysis. 08 hours

Planning of Projects: Network analysis estimating activity times, resource allocation and smoothing, performance analysis, budgetary control. 08 hours

Human environment: Industrial Ergonomics, work study , incentive schemes, theories of motivation, human behavior.

Control of manufacture 08 Hours

Quantity control : ordering systems, inventory optimization, line-of balance charts , job sequencing, work loading introduction to material requirements planning.

Quality control: planning, product quality, sampling, total quality control , plant maintenance and reliability.

Cost Control: Elements of product cost, absorption and marginal costing , job costing, process costing.

Ref.

10. Production Planning Control and Industrial Management
Jain K C Aggarwal Dr. L N

11. Modern Techniques of Production /Operations management
Elweed S Buffa John wiley, 1987
New York

326 SOFTWARE SYSTEMS ENGINEERING

Course Contents

1. Introduction

Historical developments, the software crisis. Managing large software projects, the role of the software engineer. The software life cycle. The relationship to other engineering disciplines.

2. Software Engineering Principles

Modularity, abstraction, generality. Separation of concerns. Anticipation of change.

3. The design process

Objectives. Modularisation, its structure and representation. Interfacing modules.

4. Software specification

Operational and descriptive specifications. Verification of specifications. Specification qualities.

5. Software quality and testing

User friendliness, portability, maintainability. Measure of quality. Software errors, methodical testing. Code reviews. Documentation. Software standards.

6. Software project management

Production process models: waterfall model, evolutionary, transformation and spiral models, Project planning and control. Cost estimation. Dealing with deviations. Risk Management.

7. Software engineering tools and environments

Classification of tools: editors, linkers, interpreters, compilers, code generators, debuggers, analysers . Computer aided software engineering.

Group Assignment

Programming project in a team

References

- Carlo GHEZZI, et al: Fundamentals of Software Engineering, Prentice Hall
- M V Zelkowitz: Principles of Software Engineering and Design, Prentice Hall

327 Engineering Management

Lectures = 80 hrs

Managerial Accounting and Finance 20 hrs

Business Units

Types of business organisations, Capital , structure, major sources of finance for business, working capital.

Book-keeping and Cost Accounting.

Theory of double entry, cash book, the petty cash book, the journal, the ledger the trial balance, profit and loss account and the balance sheet.

Management Accounting

Cost for decision making, marginal costing, profitability, long-range planning, capital investment appraisals.

ORGANISATIONS 12 hrs

The nature of individual and groups to work attitudes, job satisfaction and motivation. Leadership and being a manager. Training and development of human resources.

THE ECONOMY AND INDUSTRIAL POLICY OF SRI LANKA 10 hrs

Natural resources population growth, structure of the economy and balance in the economy factors inhibiting growth, balance of payments.

The role of the government and its instinstitutions with regard to industrial development.

MARKETING

The marketing function, marketing system and marketing concept. Importance of marketing in the economy, customer relations.

PRODUCTIVITY AND QUALITY TECHNIQUES 12 hrs

Understanding operations and the system approach to operations.

Productivity – Changes, improvements and costs.
Capacity decisions, facility locations and material management.
Quality Management – Quality control, quality assurance, total quality management and ISO 900 series. Costs of Quantity.

QUANTITATIVE TECHNIQUES 12 hrs

Techniques required for managerial decisions. Statistical inference, correlation and regression, time series analysis, linear programming and network analysis.

PUBLIC ADMINISTRATION

Public administration in Sri Lanka, politics, public administration, and development. Provincial administration. Public policy analysis, development planning, & economic policy. Public enterprises management.

References:

1. W W Bigg, R E G Perrings, “Book-keeping and Accounts”, ELBS Ltd
2. Alan Pizzey, “Accounting and Finance”, Holt , Rinerhart and Winston.
3. John Sizer, “An Insight into Management Accounting”, Penguin Books.
4. Ruston S Davar, “Modern Marketing Management””, Universal Book Stall, New Delhi
5. William M Luther “The Marketing Plan- How to prepare and Implement it”, American Management Association.
6. Mark A Vonderembase, Gregory P White “Operations Management – Concepts, Methods, and Strategies” , West Publishing Company
7. Richard B Chase, Nicholas J Acquilano “Production and Operations Management”, A Life Cycle Approach”, Richard D Irwin Inc.
8. Charles B Handy, “Understanding Organizations”, Penguin Education.
9. Andrew M Pettigrew “Organizational Behaviour”, Penguin Education