Subject : Elect & Electronic Measurement

Subject Code : ECE305

L	T	P	Full marks 100 Th (80+20)
3		2	Hours 42

1. **Introduction to Measurements** – **06 hrs**
   Block diagram of measurement system, characteristics of measurement system, Accuracy & precision, Repeatability, range, linearity and offsets. Errors and its types. Calibration of instruments.

2. **Analog Instruments** - **06 hrs**
   Construction and principle of operation of moving coil, moving iron, Dynamometer, Thermal and Rectifier type deflecting instruments. Deflecting, controlling and damping torques, extension of instrument ranges using shunts, multipliers and instrument transformers, multi meters, meager, localization of cable faults.

3. **DC & AC Bridges** : **06 hrs**
   Wheat stone bridge, Kelvin brifge, Kelvins double bridge AC bridge concept, Maxwell bridge, shearing bridge.

4. **ELECTRONIC INSTRUMENTS** – **04 hrs**
   Electronic Voltmeter, Electronic Multi meters, Digital Voltmeter, and Component Measuring Instruments: Q meter, Vector Impedance meter, RF Power & Voltage Measurements, Introduction to shielding & grounding.

5. **OSCILLOSCOPES** – **06 hrs**
   Basic CRO concept, CRO Probes, Techniques of Measurement of amplitude, frequency, Phase Angle, time period, time delay, Multi beam, multi trace, Storage & Sampling Oscilloscopes, Digital Storage Oscilloscope.

6. **SIGNAL GENERATION AND SIGNAL ANALYSIS** – **06 hrs**
   Sine wave generators, multi function generator, Signal Analysis - Measurement Technique, Wave Analyzers, and Frequency - selective wave analyzer, Heterodyne wave analyzer, Harmonic distortion analyzer, and Spectrum analyzer.

7. **TRANSDUCERS** - **08 hrs**
   Transducers and actuators, Classification, Selection Criteria, Characteristics, Working Principles and Application of following Transducers:- RTD, Thermocouples, Thermistors, LVDT, Strain Gauges, Bourdon Tubes, Accelerometers, Taco generators, Load Cell, Piezoelectric Transducers, Ultrasonic Flow Meter.

Subject – Elect & Electronic Measurement Lab

Subject Code – ECE309

List of Practical's

1. Instrument workshop- observe the construction of PMMC, Dynamometer, Electro thermal and Rectifier type instrument,
Oscilloscope and digital multi meter
2. Calibrate moving iron and electrodynamometer type ammeter/voltmeter by potentiometer
3. Calibrate dynamometer type Wattmeter by potentiometer
4. Calibrate A.C. energy meter
5. Measure the resistivity of material using Kelvin Double Bridge
6. Measurement of Power using Instrument transformer
7. Measurement of Power in Poly phase circuits
8. Measurement of Frequency by Wien Bridge using Oscilloscope
9. Measurement of Inductance by Anderson Bridge
10. Measurement of Capacitance by De Sauty Bridge
11. Measurement of frequency by CRO using lissajos figure
12. Study of two Channel Voltage to Circuit transmitter (V-I Transmitter)
13. Study of two Channel I-V Receiver (Converter).
14. Temperature measurement using AD590 Semiconductor temperature sensor.
15. Displacement measurement by Capacitive Transducer.
16. Pressure & Displacement measurement by Linear Variable Displacement Transducer (LVDT).
17. Study of load cell. (To study the load cell behavior for tensile & compressive load).
18. Torque measurements by Strain Gauge Transducer.
19. Measurement of linear displacement using Inductive Displacement Transducer.
20. Measurement of speed using Magnetic Pick-Up Proximity Sensor.
21. Relative Humidity measurement using Capacitive Transducer.
22. Displacement measurement by Magnetic Bi-Polar Digital Position Sensor (using Hall Effect).
23. Measurement of angular speed by Stroboscope.
24. Studies of L.D.R
25. Studies of Photo Diodes & Photo Voltaic cells.
26 Study of transducers and measurement of parameters

Reference Books

1. Golding E.W. & Wides F.C. : Electrical Measuring Instruments & Measurements ; Wheeler
2. Electronic Instrumentation – H.S. Kalsi, ISTE/EXCEL BOOKS
3 Singh:Industrial Instrumentation &control 2/e Tata Mcgraw-Hill,NewDel
4 Sawhney A K : A course in Electrical & Electronic Measurements & Instruments, Dhanpat rai
5 Kalsi:Electronic Instrumentation TMH
6 Heltrick A.D. & Cooper W.D. : Modern Electronic Instrumentation & Measuring Instruments; Wheeler
7 Patranabis D: Sensors & Transducers, Wheeler 96
8 R.V.Jalgaonkar.: Electronics Instrumentation.
9 Sutko: Industrial Instrumentations
10 Bolton W: Instrumentation & Process Measurement, Universities Press
11 Reissland: Electrical Measurement, New Age International

Subject :Electrical Technology
Subject Code : ECE304

L	T	P	Full Marks 100 (80+20)
3		2	Hours - 42

Objectives:
This is a foundation course to understand the basic principles and behavior of electrical circuits, electrical power apparatus and utilization of electrical energy.

1. Electrical Engg Fundamentals (5 hrs)

Introduction to electrical circuits: Electric field, electric current, potential and potential difference, electric power, basic circuit components, ohm's law.
Sources and its types, Ideal and practical sources, Source Conversion, independent and dependent sources, Energy Stored in Inductor and Capacitor, series, parallel and series and parallel circuit.

2. DC Networks & Theorems: (05 hrs)

Laws and Theorems applicable to DC networks (KCL & KVL, Node voltage & Mesh current analysis, Star-Delta and Delta-Star conversion, Superposition principle, Thevenin & Norton theorem),Transients in R-L and R-C circuits with DC excitation, Simple problems.

3. AC Fundamentals (6 hrs)

Single-Phase AC Circuits: Single-phase EMF Generation, Average and Effective value of periodic ac signals, Peak factor & Form factor, Phasor and Complex representation of sinusoids, Power factor, complex power.
Three-Phase AC Circuits: Comparison between single-phase and three-phase systems, three phase EMF Generation, Line and Phase quantities in star and delta networks,

4. Magnetic circuits & Transformers (10 hrs)

Introduction to Magnetic Circuits: Introduction to Electromagnetism, B-H curve, Permeability, Reluctance, Solution of magnetic circuits, Hysteresis and Eddy current loss.
Single-Phase Transformers: Construction and principle of operation, EMF Equation, Transformation ratio, Practical and Ideal transformers, Transformer losses, Brief idea on Transformer Phasor diagram and transformer rating, Auto transformer. Introduction to 3 phase transformer

5. D C Machines (8 hrs)

D.C. Machines: Principle of operation, construction, classification of DC machines, EMF equation of DC generator, Speed Equation of DC Motor. Series , shunt and compound dc moters.

6. AC Machines **(4 hrs)**

Induction Motors: Introduction to Single-phase and Three-phase Induction Motors, Concept of Slip. Synchronous motors and special types of ac motors.

7. Power Systems: **(04 hrs)**

Introduction to generation, transmission and distribution of AC Power, basic idea on grounding, and safety, illumination

Text/reference books:

1. Rizzoni,Principles and Applications of Electrical Engineering., McGrawHill
2. Hughes, "Electrical & Electronic Technology", Ninth Edition Pearson Education.
3. V.D.Toro, "Basic Electrical Engineering", Prentice-Hall of India.
4. B.L.Theraja, A.K.Theraja, "A textbook of Electrical Technology" S.Chand. Ltd.
5. Rajendra Prasad, "Fundamentals of Electrical Engineering", PHI,
6. 6.D P khothari and I J Nagratha "Basic electrical engineering" 2nd ed, TMH.
7. N.N.ParkerSmith,"Problems in Electrical Engineering", CBS Publisher

Subject : Electrical Technology Laboratory
Subject Code :- ECE308

List of Experiments :

1. Connection and measurement of power consumption of various lamps.
2. Measurement of armature and field resistance of DC machine.
3. V-I Characteristics of incandescent lamps and time fusing current characteristics of a fuse.
4. Calculation of current, voltage and power in series R-L-C circuit excited by single phase AC supply and calculation of power factor.
5. Study of various parts of DC machine.
6. Study of single phase induction motor and fan motor.
7. Verification of superposition, Thevenin's and Norton's theorem.
8. Study of single phase energy meter.
9. Open circuit and short circuit test of single phase transformer.
10. Study of solar photo voltaic system.

Subject : Electromagnetic Field Theory
Subject Code : ECE306
Full marks 100 (80+20)
L T P
3 0 2

Course Objective: To familiarize the student to the concepts and calculations pertaining to electric, magnetic and electromagnetic fields so that an in depth understanding of transmission line, waveguides, antenna and other electronic devices are possible.

Course Outcome:

1. Ability to state and apply the principles of Coulombs Law and the Superposition Principle to electric fields in the Cartesian, cylindrical and spherical coordinate systems.
2. Ability to determine the electric field intensity resulting from various configurations of charge distributions.
3. Ability to apply Gauss' Law to highly symmetric charge distributions.
4. Ability to determine the electric potential and its relation to electric field intensity.
5. In depth understanding of Ohms Law, conductivity, and current in conductors, as well as an understanding of electric fields in dielectric and conducting materials.
6. In depth study of capacitance and capacitors, and calculations of various geometries.
7. In depth study of electrostatic boundary-value problems by application of Poisson's and Laplace's equations.
8. Ability to analyze and classify magnetic materials, and solve magneto static field problems using Biot-Savart law and Ampere's circuit law with the associated boundary conditions.
9. In depth understanding of time-varying electromagnetic field as governed by Maxwell's equations. 10. Ability to understand the general electromagnetic wave propagation.
11. Ability to interpret the effects of lossy and low loss dielectrics upon the propagation of EM waves.
12. In depth understanding of plane wave reflection and transmission at conductor and dielectric boundaries.

Syllabus

1. STATIC ELECTRIC FIELD (12 hrs)

Topics: Introduction to Co-ordinate System – Rectangular – Cylindrical and Spherical Co- ordinate System – Introduction to line, Surface and Volume Integrals – Definition of Curl, Divergence and Gradient – Meaning of Stokes theorem and Divergence theorem Coulomb's Law in Vector Form – Definition of Electric Field Intensity – Principle of Superposition – Electric Field due to discrete charges – Electric field due to continuous charge distribution – Electric Field due to charges distributed uniformly on an infinite and finite line – Electric Field on the axis of a uniformly charged circular disc – Electric Field due to an infinite uniformly charged sheet.

Electric Scalar Potential – Relationship between potential and electric field – Potential due to infinite uniformly charged line – Potential due to electrical dipole – Electric Flux Density – Gauss Law – Proof of Gauss Law – Applications.

2. STATIC MAGNETIC FIELD (08 hrs)

Topics: The Biot-Savart Law in vector form – Magnetic Field intensity due to a finite and infinite wire carrying a current I – Magnetic field intensity on the axis of a circular and rectangular loop carrying a current I – Ampere's circuital law and simple applications. Magnetic flux density – The Lorentz force equation for a moving charge . – Force on a wire carrying a current I placed in a magnetic field – Torque on a loop carrying a current I – Magnetic moment – Magnetic Vector potential

3. ELECTRIC AND MAGNETIC FIELDS IN MATERIALS (10 hrs)

Topics: Poisson's and Laplace's equation – Electric Polarization-Nature of dielectric materials- Definition of Capacitance – Capacitance of various geometries using Laplace's equation – Electrostatic energy and energy density – Boundary conditions for electric fields – Electric current – Current density – point form of ohm's law – continuity equation for current. Definition of Inductance – Inductance of loops and solenoids – Definition of mutual inductance– simple examples. Energy density in magnetic fields– Nature of magnetic materials– magnetization and permeability– magnetic boundary conditions.

4. TIME VARYING ELECTRIC AND MAGNETIC FIELDS (06 hrs)

Topics: Faraday's law – Maxwell's first Equation in integral form from Faraday's Law – Equation expressed in point form. Displacement current – Ampere's circuital law in integral form – Modified form of Ampere's circuital law as Maxwell's second equation in integral form – Equation expressed in point form. Maxwell's four equations in integral form and differential form. Pointing theorem .Instantaneous Average and Complex Pointing Vector.

5. ELECTROMAGNETIC WAVE (06 hrs)

Topics: Derivation of Wave Equation – Uniform Plane Waves – Maxwell's equation – Wave equation – Plane waves in free space and in a homogenous material. Wave equation for a conducting medium – Plane waves in lossy dielectrics – Propagation in good conductors – Skin effect. Linear, Elliptical and circular polarization – Reflection of Plane Wave from a conductor – normal incidence – Reflection of Plane Waves by a perfect dielectric – normal and oblique incidence. Dependence on Polarization, Brewster angle.

Text Books:

1 Fundamentals of Electromagnetic for Engineering, N.N. Rao, Pearson education, New Delhi. Reference Books:

1 Engineering electromagnetic, William H. Hayt, TMH, and New Delhi.

2 Elements of Electromagnetic, Mathew N.O Sadiku, Oxford University press, New Delhi

3 Electromagnetic , Joseph A. Edminister, TMH, New Delhi

4 Electromagnetic waves and radiating system, E.C Jordan and K.G Balman, Pearson Education, New Delhi. Evaluation

Subject : Electromagnetic Field Theory Lab
Subject Code : ECE310

List of Experiments for EMF Theory:

Expt 1: Measurement of electrical field pattern between two circular plates

Expt 2: Electrical Field and Potential inside the Parallel Plate Capacitor

Expt 3: Capacitance and Inductance of two parallel lines at fixed distance

Expt 4: Simulation of Electric Field and Potential Inside Capacitors.

Expt 5: Magnetic Field outside a Straight Conductor.

Expt 6 : Measurement of Magnetic Field of Coils.

Expt 7 : Magnetic Force on a Current Carrying Conductor.

Expt 8. : Experiment on filled measurement around solenoid

Expt 9 : Experiment on Magnetic Induction through transformer

Expt 10 : Hertz's experiment to demonstrate production and reception of radio waves

Expt 11 : E.M Wave Radiation and Propagation of a radiating conductor such as Antenna.

Expt 12 : Experiment on directivity and radiating pattern around conductor carrying current

Expt 13 : Experiment on simple AM Transmitter and Receiver

Expt 14 : E.M Wave Transmission and Reflection measurement experiment.

MATLAB / Software Based Experiments through its toolbox

Lab 1 Time domain reflectometry

Lab 2 SWR measurements using slotted waveguide

Lab 3 Method of moments (MoM) applied to electrostatics

Lab 4 Finite difference time domain (FDTD) method in 2D

Lab 5 Microwave power measurement

Lab 6 Reflection of plane waves

Lab 7 Modes of a rectangular waveguide

Lab 8 Antenna measurements

Subject :Electronic Devices and Circuits

Subject Code : ECE303

L T P **Full Marks- 100 (80+20)**

3 2

1. SEMICONDUCTOR & PN Junction Diodes : (10 hrs)

Difference between Conductor, Insulator and Semiconductor, Mobility and conductivity, Charge densities in a semiconductor, Fermi Dirac distribution, Carrier concentrations and Fermi levels in semiconductor, Generation and recombination of charges, Diffusion and continuity equation, P and N Type semiconductor, Formation of homogenous and hetrojuntion diodes and their energy band diagrams, PN Junction, V-I characteristics, Small signal models of diode, Diode as a circuit element, Diode parameters and load line concept, Applications of diodes in rectifier, Clipping, Clamping circuits and voltage multipliers, Breakdown diodes, Schottky diodes, and Zener diode as voltage regulator

2. TRANSISTORS : (06 hrs)

Characteristics, Current components, Current gains: alpha and beta. Variation of transistor parameter with temperature and current level, Operating point, Hybrid model, DC model of transistor, h-parameter equivalent circuits. CE, CB and CC configuration. DC and AC an analysis of single stage CE, CC (Emitter follower) and CB amplifiers AC & DC load line, Ebers-Moll model. Biasing & stabilization techniques. Thermal runaway, Thermal stability.

3. JFET & MOSFET : (06 hrs)

Construction and operation, Noise performances of FET, Parasitic of MOSFET, Small signal models of JFET & MOSFET, Biasing of JFET's & MOSFET's, Low frequency single stage CS and CD (source follower) JFET amplifiers, FET as voltage variable resistor and FET as active load, CMOS.

4. SMALL SIGNAL AMPLIFIERS : (06 hrs)

Analysis of BJT and FET multistage amplifier, DC and RC coupled amplifiers. Frequency response of single and multistage amplifier, mid-band gain, gains at low and high frequency. Analysis of DC and differential amplifiers, Cascade and cascade configuration of multistage amplifiers (CE-CE, CE-CB, CS-CS and CS-CD), Darlington pair

5. FEEDBACK AMPLIFIERS & Oscillators : (06 hrs)

Classification, Feedback concept, Feedback Topologies, Transfer gain with feedback, General characteristics of negative feedback amplifiers. Analysis of voltage-series, voltage-shunt, current-series and current-shunt feedback amplifier. Stability criterion.
OSCILLATORS- Classification. Criterion for oscillation. Tuned collector, Hartley, Colpitts, RC Phase shift, Wien bridge and crystal oscillators, pulse generator.

6. TUNED AMPLIFIER : (06 hrs)

Band Pass Amplifier, Parallel resonant Circuits, Band Width of Parallel resonant circuit. Analysis of Single Tuned Amplifier, Primary & Secondary Tuned Amplifier with BJT & FET, Double Tuned Transformer Coupled Amplifier. Stagger Tuned Amplifier. Pulse Response of such Amplifier, class C tuned amplifiers, Shunt Peaked Circuits for Increased Bandwidth.(Discussion and use as RF and IF stages)

7. POWER AMPLIFIERS – (06 hrs)

Classification, Power transistors & power MOSFET (DMOS, VMOS). Output power, power dissipation and efficiency analysis of Class A, class B, class AB, class C, class D and class E amplifiers as output stages. Push pull amplifiers with and without transformers, Complementary symmetry & quasi complimentary symmetry amplifiers

Subject : Electronic Devices and Circuts
Subject Code : ECE307

List of experiments

1. Study the following devices: (a) Analog & digital multimeters (b) Function/ Signal generators (c) Regulated d. c. power supplies (constant voltage and constant current operations) (d) Study of analog CRO, measurement of time period, amplitude, frequency & phase angle using Lissajous figures.
2. Plot V-I characteristic of P-N junction diode & calculate cut-in voltage, reverse Saturation current and static & dynamic resistances.
3. Plot V-I characteristic of zener diode and study of zener diode as voltage regulator. Observe the effect of load changes and determine load limits of the voltage regulator.
4. Plot frequency response curve for single stage amplifier and to determine gain bandwidth product
5. Plot drain current - drain voltage and drain current – gate bias characteristics of field effect transistor and measure of Idss & Vp
6. Application of Diode as clipper & clamper
7. Plot gain- frequency characteristic of two stage RC coupled amplifier & calculate its bandwidth and compare it with theoretical value.
8. Plot gain- frequency characteristic of emitter follower & find out its input and output resistances.
9. Plot input and output characteristics of BJT in CB, CC and CE configurations. Find their h-parameters
10. Study half wave rectifier and effect of filters on wave. Also calculate theoretical & practical ripple factor.
11. Study bridge rectifier and measure the effect of filter network on D.C. voltage output & ripple factor.
12. Oscillator circuits

Diploma in Engineering (All branch except Mining, Arch & Non Tech)

Semester : Third

Subject Title : Engineering Mathematics-III

Subject Code: 301

Teaching and Examination Scheme:

Teaching Scheme			Examination Scheme					
L TH	T	P	Full Marks.	External Exam Marks	Internal Exam Marks	External Pas Marks	Total Pass Marks	Duration of External Exams
03	01		100	80	20	26	40	3 Hrs

NOTE:Internal marks will be allotted on the basis of two snap tests and 2 assignment of equal marks to be conducted by the faculty teaching the subject.

Rationale:

The subject is extension of Engineering Mathematics – 1 & 2 of First year and stepping into the prerequisites to learn Applied Mathematics applicable in engineering solutions. Engineering Mathematics lay down the foundation to understand and express principles and laws involved in other technological subjects. The study of Engineering Mathematics will help to develop the skills essential for new emerging avenues.

Objective:

The student will be able to acquire knowledge of mathematical terms, concepts and principles. They can acquire sufficient mathematical techniques and can develop the ability to apply mathematical methods to solve technical and day to day practical problems and to execute management plans with precision.

Sub Objective:

This course is divided into five units. After completion of this course one could become able to learn the following.

- Intuitive meaning and Methods of finding integration definite integration and its properties.
- Application of Integration in finding Area, volume of irregular shapes.
- Methods of solving differential equation of first order and first degree.
- Methods for finding approximate roots by using bisection, Regula-falsi, Newton-Raphson method, Gauss elimination, Jacobi and Gauss- Seidal methods.
- Use of Binomial, Normal and Poisson distributions for solving different examples.

- Use of Laplace transform for solving problems of Differential Equations.
- Use of Fourier series for expansion of function at the given intervals

Contents: Theory

Chapter	Name of the Topic	Hours	Marks
01	**Integration:** 1.1 Definition of integration as anti-derivative. Integration of standard function. 1.2 Rules of integration (Integrals of sum, difference, scalar multiplication). 1.3 Methods of Integration. 1.3.1 Integration by trigonometrical transformation. 1.3.2 Integration by substitution 1.3.3 Integration by parts. 1.3.4 Integration of rational and irrational functions. 1.3.5 Integration by Partial fractions.	7	16
	1.4 Definite Integration. 1.4.1 Concept of definite integrations with examples. 1.4.2 Properties of definite integral with simple problems.	3	
	1.5 Applications of definite integrals. 1.5.1 Area under the curve. 1.5.2 Area bounded by two curves.	3	
2	**Differential Equation** 2.1 Definition of differential equation, order and degree of differential equation. Formation of differential equation. 2.2 Solution of differential equations of first order and first Degree such as variable separable form, reducible to Variable separable, Homogeneous and Linear Differential Equation.	6	16
	2.3 **Applications of Differential equations.** 2.3.1 Rectilinear motion (motion under constant and variable acceleration) 2.3.2 Newton's Law of Cooling	3	
3	**Numerical Methods** **3.1 Solution of algebraic equations** Bisection method, Regula falsi method and Newton–Raphson method.	3	16
	3.2 Solution of simultaneous equations containing 3 unknowns		

	3.2.1 Gauss elimination method. 3.2.2 Jacobi's Iterative method. 3.3.3 Gauss Seidal method.	3	
	3.3 Interpolation 3.3.1 Concept of interpolation and extrapolation. 3.3.2 Different operators $(\Delta, \nabla \& E)$,relation between them, some problems based on operators , formation of Difference Table. 3.3.3 Newton's Forward and Backward difference interpolation formulae. 3.3.4 Lagrange's interpolation formula. 3.3.5 Problems based on above.	6	
	3.4 Numerical Differentiation &Integration. 3.4.1 Newton's forward and backward difference formulae for first and second order differentiation at any point. 3.4.2 Numerical integration Trapezoidal rule and Simpson's 1/3rd rule.	3	
4	**4.1 Probability:** 4.1.1 Definition of random experiment, sample space, event occurrence of event and types of events (impossible, mutually exclusive, exhaustive, equally likely) 4.1.2 Definition of probability, addition and multiplication theorems of probability.	05	16
	4.2 Probability Distribution 4.2.1 Binomial distribution. 4.2.2 Poisson's distribution. 4.2.3 Normal distribution 4.2.4 Simple examples based on above .	05	
5	**Laplace Transform** 5.1 Definition of Laplace transforms Laplace transform of standard functions. 5.2 Properties of Laplace transform such as Linearity, first shifting, second shifting, multiplication by t^n, division by t. 5.3 Inverse Laplace transforms. Properties-linearly first shifting, second shifting. Method of partial fractions,	3	16
6	**Fourier Series** 6.1 Definition of Fourier series (Euler's formula). 6.2 Series expansion of continuous functions in the intervals $(0,2l),(-l,l),(0,2\pi),(-\pi,\pi)$	3	

7	**Linear Programming** **7.1 Introduction** **7.2 Solution of Linear Programming problem (LPP) by Graphical Method.**	3	
	TOTAL:	56	80

Tutorial: Tutorials are to be used to get enough practice for solving problems. It is suggested that in each tutorial at least five problems should be solved.

Learning Resources:

Text Book:

Sr. No	Title	Authors	Publications
1	Higher Engg. Mathematics	B. S. Grewal	Dhanpat Rai

Ref. Books:

Sr. No	Title	Authors	Publications
1	Engineering Mathematics	H.K.Das	S.Chand & Company LTD, New Delhi
2	Higher Engineering Mathematics	B.V,Ramana	Mcgraw Hill Education (India) Private limited , New Delhi
3	Practical Mathematics	I.B. Prasad	Khanna
4	Introductory Method of Numerical Analysis	S.S.Shastri	P.H.I
5	Linear Programming	G. Hadley	
6	A text book for class 12, Part- I & II	NCERT	NCERT, Delhi

Note:

In board examination, question setter may be advised to select 20% questions of objective, 30% of short type and remaining 50% of long type based on basic concepts, formula and calculations respectively.

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