4-YEAR UNDERGRADUATE PROGRAM (FYUGP)
WITH MAJOR IN PHYSICS
UNDER THE NEW CURRICULUM AND
CREDIT FRAMEWORK, 2022

UNDERGRADUATE PHYSICS
SYLLABUS

University of North Bengal
2023

COURSE STRUCTURE

Major Discipline: Physics

Semester I - II

SEM	Paper Code	Course Paper
Sem-I	UPHYMAJ 11001	Mathematical Physics-I
Sem-II	UPHYMAJ 12002	Mechanics -I
Sem-I	UPHYSEC 11001	Basic Electrical Circuits and Measurements
Sem-II	UPHYSEC 12002	Renewable Energy and Energy Harvesting

Minor Discipline: Physics

Semester I - II

SEM	Course	Course Paper
Sem-I	UPHYMIN 10001	Mechanics
Sem-II	UPHYMIN 20002	Mechanics

Multidisciplinary Course

Semester II

SEM	Course	Course Paper
Sem-II	UPHYMDC 10001/10002	Introduction to Astronomy

Major Subjects Syllabus

(Credits: Theory-03, Practical-01)

UPHYMAJ 11001 (Theory): Mathematical Physics-I
45 Lectures; 3 Credits

Unit 1: Vector Algebra [10 hours]

Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume, respectively. Scalar and Vector fields.

Unit 2: Vector Calculus [12 hours]

Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities. Vector Integration: Ordinary Integrals of Vectors. Multiple integrals. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of vector fields. Flux of a vector field. Gauss's divergence theorem, Green's and Stokes Theorems and their applications.

Unit 3: Orthogonal Curvilinear Coordinates [8 hours]

Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

Unit 4: Differential Equations [15 hours]

First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for initial value problems.

Reference Books:

- Mathematical Methods for Physicists, G. B. Arfken, H. J. Weber, F. E. Harris, 2013, Elsevier.
- An introduction to ordinary differential equations, E. A. Coddington, 2009, PHI learning.
- Differential Equations, George F. Simmons, 2007, McGraw Hill.
- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
- Mathematical methods for Scientists and Engineers, D. A. McQuarrie, 2003, Viva Book.
- Advanced Engineering Mathematics, D. G. Zill and W. S. Wright, Jones and Bartlett Learning.
- Mathematical Physics, Goswami, 1st edition, Cengage Learning.
- Engineering Mathematics, S. Pal and S. C. Bhunia, 2015, Oxford University Press.
- Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
- Essential Mathematical Methods, K. F. Riley & M. P. Hobson, 2011, Cambridge Univ. Press.
- Mathematical methods in the Physical Sciences, M. L. Boas, 2005, Wiley.

UPHYMAJ 11001 (Practical): Mathematical Physics-I Lab
30 Lectures; Credit-1

Errors and Error Analysis in scientific computing:

Floating point numbers, single and double precision arithmetic, underflow & overflow. Truncation and round-off errors, Absolute and relative errors.

Introduction to programming in Python:

Introduction to programming: constants, variables and data types, dynamical typing, operators and expressions, modules, I/O statements, iterables, compound statements, indentation in python, the if-elif-else block, for and while loops, nested compound statements, lists, tuples, dictionaries and strings, basic file handling, basic ideas of object oriented programming.

Basic Programs in Python along with algorithms: (Without using any library function)

- Input a list of numbers and obtain their sum & average
- Finding odd/even from a list of numbers
- Find the largest / smallest number of the list and its location in the list
- Sorting a list of numbers in ascending and descending order
- Finding sum and product of a series (e.g. $\sum_n \quad n^2, \sum_i \quad x^i, \prod_n \quad x^n$, etc.)
- Simple problems in matrix: Addition, subtraction, multiplication, equality, etc.
- Dot product, cross product, triple product of vectors
- Verify vector identities
- Print the Fibonacci sequence, Factorial of Number
- Find the frequency of each element in an array, etc.
- Sort words in alphabetical order, Remove punctuation from a string, Reverse a string
- Convert list to string, Concatenate two strings

File handling tools may also be used for the above programs

Reference Books:

- Introduction to Numerical Analysis, S. S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
- Learning with Python-how to think like a computer scientist, J. Elkner, C. Meyer, and A. Downey, 2015, Dreamtech Press.
- Introduction to computation and programming using Python, J. Guttag, 2013, Prentice Hall India.
- Effective Computation in Physics- Field guide to research with Python, A. Scopatz and K. D. Huff, 2015, O'Rielly.
- A first course in Numerical Methods, U. M. Ascher & C. Greif, 2012, PHI Learning.
- Elementary Numerical Analysis, K. E. Atkinson, 3 rd Edn., 2007, Wiley India Edition.
- Numerical Methods for Scientists & Engineers, R. W. Hamming, 1973, Courier Dover Pub.
- An Introduction to Computational Physics, T. Pang, 2nd Edn., 2006,Cambridge Univ. Press.
- Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.

UPHYMAJ 12002 (Theory): Mechanics -I
45 Lectures; 3 Credits

Unit 1: Fundamentals of Dynamics [9 hours]
Reference frames. Inertial frames – Review of Newton's laws of motion. Galilean transformations; Galilean invariance. Momentum of variable-mass system: motion of rocket. Dynamics of a system of particles – conservation of linear momentum, Centre of mass. Conservative and non-conservative forces. Potential energy. Stable and unstable equilibrium. Force as gradient of potential energy. Law of conservation of energy.

Unit 2: Rotational dynamics [10 hours]
Rotation about a fixed axis – Moment of Inertia, Kinetic energy, Angular momentum and Torque. Conservation of angular momentum. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Motion involving both translation and rotation.

Unit 3: Elasticity [6 hours]
Hooke's law, Stress-strain diagram, Elastic moduli – relation between elastic constants, Poisson's ratio – expression of Poisson's ratio in terms of elastic constants. Work done in stretching and twisting a wire.

Unit 4: Gravitation and Central Force Motion [12 hours]
Law of gravitation. Gravitational potential energy, self-energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. Motion of a particle under the central force field. Two-body problem, its reduction to one-body problem and its solution. Effective potential of a particle in gravitational field, Trajectory of a particle in inverse-square force potential. Kepler's laws. Escape velocity, satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness.

Unit 5: Non-Inertial Systems [8 hours]
Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems.

Reference Books:

- An introduction to mechanics, D. Kleppner, R. J. Kolenkow, 1973, McGraw-Hill.
- Mechanics, Berkeley Physics, Vol.1, C. Kittel, W. Knight, et.al. 2007, Tata McGraw-Hill.
- Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
- Analytical Mechanics, G. R. Fowles and G. L. Cassiday. 2005, Cengage Learning.
- Feynman Lectures, Vol. I, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education
- Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
- Mechanics, D. S. Mathur, S. Chand and Company Limited, 2000
- University Physics. F. W Sears, M. W Zemansky, H. D. Young 13/e, 1986, Addison Wesley

- Physics for scientists and Engineers with Modern Phys., J. W. Jewett, R. A. Serway, 2010, Cengage Learning
- Theoretical Mechanics, M. R. Spiegel, 2006, Tata McGraw Hill.

UPHYMAJ 12002 (Practical): Mechanics-I Lab

30 Lectures; Credit-1

1. Measurements of volume of a hollow cylinder using Vernier calipers, Screw gauge and Traveling microscope.
2. To determine the height of a building using a Sextant.
3. To study the motion of a spring and calculate (a) Spring Constant (b) Value of g.
4. To determine the Moment of Inertia of a Flywheel.
5. To determine g and velocity for a freely falling body using Digital Timing Technique.
6. To determine the moment of inertia of a) cylindrical, b) rectangular bar about an axis passing through its C.G. using static method.
7. To determine the moment of inertia of a) cylindrical, b) rectangular bar about an axis passing through its C.G. using dynamic method.
8. To determine the value of g by Bar Pendulum.
9. To determine the value of g by Kater's Pendulum.
10. Determination of rigidity modulus of the material of a wire by static method.
11. Determination of rigidity modulus of the material of a wire by dynamic method.
12. To determine the modulus of rigidity of a wire by Maxwell's needle.
13. To determine the Young's Modulus of a wire by Optical Lever method.
14. To determine the elastic constants of a wire by Searle's method.

Reference Books:

- Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
- Engineering Practical Physics, S. Panigrahi & B. Mallick,2015, Cengage Learning India Pvt. Ltd.
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
- Physics through experiments, B. Saraf, Vikas Publications, 2013
- A lab manual of Physics for undergraduate classes, 1st Edition, Vikas Publications.
- B.Sc. Practical Physics Revised Ed, C. L. Arora, S. Chand & Co. 2007

Skill Enhancement Course

(Credits: Theory-02, Practical/Tutorial/Field Visit/Demonstration-01)

UPHYSEC 11001 (Theory): Basic Electrical Circuits and Measurements

30 Lectures; 2 Credits

Unit 1: Basic Electricity Principles [4 hours]

Voltage, Current, Resistance and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC Electricity and DC Electricity. Familiarization with Voltmeter, Ammeter and Multimeter.

Unit 2: Understanding Electrical Circuits [6 hours]

Main electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money.

Unit 3: Generators and Transformers [5 hours]

DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.

Unit 4: Solid-State Devices [5 hours]

Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources.

Unit 5: Electrical Protection [5 hours]

Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Interfacing DC or AC sources to control elements (relay protection device).

Unit 6: Electrical Wiring [5 hours]

Different types of conductors and cables. Basics of wiring – Star and Delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation. Solid and stranded cable. Conduits. Cable trays. Splices: wire nuts, crimps, terminal blocks, split bolts, and solder. Preparation of the extension board.

Reference Books

- A textbook in Electrical Technology, B. L. Theraja, S. Chand & Co.
- A textbook of Electrical Technology, A. K. Theraja
- Performance and design of AC machines, M. G. Say ELBS Edn.
- A. K. Sawhney, A Course in Electrical & Electronic Measurements & Instrumentation, Dhanpatrai & Co. (P) Ltd.

- A. D. Helfrick & W. D. Cooper, Modern Electronic Instrumentation and Measurement Techniques PHI, 2016.
- D. C. Kulshreshtha, Basic Electrical Engineering, Mc Graw Hill Publications, 2019.
- David G. Alciatore and Michel B. Histand, Introduction to Mechatronics and Measurement Systems, 3rd, Tata McGraw Hill Education Private Limited, New Delhi., 2005.
- Vincent Del Toro, Electrical Engineering Fundamentals, Prentice Hall India2009

UPHYSEC 11001 (Practical): Basic Electrical Circuits and Measurements-Lab
30 Lectures; Credit-1

Experiments:

(Teaching of soldering skills for constructing electrical circuits is recommended)

1. Designing a Voltmeter using a Galvanometer.
2. Designing an Ammeter using a Galvanometer.
3. Measurement of Resistance using P. O. Box.
4. Measurement of Resistance using Meter Bridge.
5. Measurement of e.m.f. of a cell using Potentiometer.
6. Designing Half-wave / Full-wave / Bridge rectifier circuits with and without filter and determination of percentage regulation.
7. Measurement of Capacitance using an A. C. Bridge.
8. Measurement of Inductance using an A. C. Bridge.

Reference Books:

- A. K. Sawhney, A Course in Electrical & Electronic Measurements & Instrumentation, Dhanpatrai & Co. (P) Ltd.
- Helfrick & Cooper, Modern Electronic Instrumentation and Measurement Techniques, Prentice Hall India Learning Private Limited.

UPHYSEC 12002 (Theory): Renewable Energy and Energy Harvesting
30 Lectures; 2 Credits

Unit 1: Fossil fuels and Alternative Sources of energy [5 hours]

Fossil fuels and nuclear energy, their limitations, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind energy, Tidal energy, Wave energy systems, Ocean Thermal Energy Conversion, Solar energy, biomass, Biogas generation, Geothermal energy, Tidal energy, Hydroelectricity.

Unit 2: Solar energy [6 hours]

Solar energy, its importance, storage of solar energy, solar pond, non-convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, sun tracking systems.

Unit 3: Wind Energy [7 hours]

Fundamentals of Wind energy, Wind turbines and different electrical machines in wind turbines.

Unit 4: Hydro Energy [5 hours]

Hydropower resources, Hydropower technologies, Environmental impact of hydropower sources.

Unit 5: Geothermal Energy [4 hours]

Geothermal resources, Geothermal technologies

Unit 6: Energy budget [3 hours]

Electrical load estimation of an establishment and energy audit.

Reference Books:

- Non-conventional energy sources, G. D. Rai, Khanna Publishers, New Delhi.
- Solar energy, M. P. Agarwal, S Chand and Co. Ltd.
- Solar energy, Suhas P. Sukhative, Tata McGraw-Hill Publishing Company Ltd.
- Godfrey Boyle, Renewable Energy, Power for a sustainable future", 2004, Oxford University Press, in association with The Open University.
- Dr. P. Jayakumar, Solar Energy: Resource Assessment Handbook, 2009.
- J. Balfour, M. Shaw and S. Jarosek, Photovoltaics, Lawrence J. Goodrich (USA).

UPHYSEC12002 (Practical): Renewable Energy and Energy Harvesting – Tutorial/ Project / Field work

30 Lectures; Credit-1

(Students will have to deliver a presentation in addition to and related to any one of the following)

1. Project report on Solar energy.
2. Project report on Hydro energy.
3. Project report on Wind energy.
4. Report on field trip to nearby Hydroelectric stations.
5. Report on field trip to nearby Solar energy parks.

Minor Subjects Syllabus

(Credits: Theory-03, Practicals-01)

UPHYMIN 10001 (Theory): Mechanics

45 Lectures; 3 Credits

Unit 1: Vectors [5 hours]

Vector algebra. Scalar and vector products. Vector differentiation.

Unit 2: Ordinary Differential Equations [5 hours]

1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients.

Unit 3: Laws of Motion [8 hours]

Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass.

Unit 4: Momentum and Energy [5 hours]

Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.

Unit 5: Rotational Motion [7 hours]

Angular velocity and angular momentum. Torque. Conservation of angular momentum.

Unit 6: Oscillations [9 hours]

Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations.

Unit 7: Elasticity [6 hours]

Hooke's law – Stress-strain diagram, Elastic moduli – Relation between elastic constants, Poisson's ratio, Expression for Poisson's ratio in terms of elastic constants, Work done in stretching and twisting a wire – Twisting couple on a cylinder.

Reference Books:

- University Physics. F. W. Sears, M. W. Zemansky and H. D. Young, 13/e, 1986. Addison-Wesley.
- Mechanics Berkeley Physics, V.1: Charles Kittel, *et al*. 2007, Tata McGraw-Hill.
- Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley.
- Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press.
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

UPHYMIN 10001 (Practical): Mechanics-Lab

30 Lectures; Credit-1

1. Measurements of volume of a hollow cylinder using Vernier calipers, Screw gauge and Traveling microscope.
2. To determine the height of a building using a Sextant.
3. To study the motion of a spring and calculate (a) Spring Constant (b) Value of g.
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- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
- Engineering Practical Physics, S. Panigrahi & B. Mallick,2015, Cengage Learning India Pvt. Ltd.
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
- Physics through experiments, B. Saraf, Vikas Publications, 2013
- A lab manual of Physics for undergraduate classes, 1st Edition, Vikas Publications.
- B.Sc. Practical Physics Revised Ed, C. L. Arora, S. Chand & Co. 2007

UPHYMIN 10002 (Theory): Mechanics
45 Lectures; 3 Credits

Unit 1: Vectors [5 hours]
Vector algebra. Scalar and vector products. Vector differentiation.

Unit 2: Ordinary Differential Equations [5 hours]
1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients.

Unit 3: Laws of Motion [8 hours]
Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass.

Unit 4: Momentum and Energy [5 hours]
Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.

Unit 5: Rotational Motion [7 hours]
Angular velocity and angular momentum. Torque. Conservation of angular momentum.

Unit 6: Oscillations [9 hours]
Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations.

Unit 7: Elasticity [6 hours]
Hooke's law – Stress-strain diagram, Elastic moduli – Relation between elastic constants, Poisson's ratio, Expression for Poisson's ratio in terms of elastic constants, Work done in stretching and twisting a wire – Twisting couple on a cylinder.

Reference Books:

- University Physics. F. W. Sears, M. W. Zemansky and H. D. Young, 13/e, 1986. Addison-Wesley.
- Mechanics Berkeley Physics, V.1: Charles Kittel, *et al*. 2007, Tata McGraw-Hill.
- Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley.
- Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press.
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

UPHYMIN 10002 (Practical): Mechanics-Lab

30 Lectures; Credit-1

1. Measurements of volume of a hollow cylinder using Vernier calipers, Screw gauge and Traveling microscope.
2. To determine the height of a building using a Sextant.
3. To study the motion of a spring and calculate (a) Spring Constant (b) Value of g.
4. To determine the Moment of Inertia of a Flywheel.
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- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
- Physics through experiments, B. Saraf, Vikas Publications, 2013
- A lab manual of Physics for undergraduate classes, 1st Edition, Vikas Publications.
- B.Sc. Practical Physics Revised Ed, C. L. Arora, S. Chand & Co. 2007

Multidisciplinary Course

(Credits: 03)

UPHYMDC 10001/10002 (Theory): Introduction to Astronomy

45 Lectures

Unit 1: Astronomical Scales [7 hours]

Astronomical Distance, Mass and time scales. Parallax, Distance measurement. Distance between Earth and Sun (Astronomical unit), Light year, Parsec, Pinhole camera for measurement of radius of the sun. Celestial Spheres. Astronomical Coordinate Systems. Construction of Galilean Telescope, other optical Telescopes and magnification power. Celestial objects visible with them.

Unit 2: Eclipse [6 hours]

Solar eclipse, Lunar eclipse, Total, annular and partial eclipses.

Unit 3: Sun [6 hours]

Transient phenomenon : Sun spot, Solar storm, Diamond ring in the Sun and the source of energy in the Sun, Tides

Unit 4: Night sky [9 hours]

Name of constellations, Nebula, Comets, Kuiper belt, Solar system, Planets with habitable conditions, Search for Extra Terrestrial Intelligence (S.E.T.I.).

Unit 5: Stars and its classifications [5 hours]

HR diagram, Normal Stars, White dwarf, Neutron star, Black hole

Unit 6: The Milky way [7 hours]

Basic structure and properties of the Milky Way.

Unit 7: Galaxies [5 hours]

Elliptical, Spiral and Lenticular galaxies, Galactic halo.

Reference Books:

- Modern Astrophysics, B. W. Carroll & D. A. Ostlie, Addison-Wesley Publishing Co.
- Introductory Astronomy and Astrophysics, M. Zeilik and S. A. Gregory, Saunders College Publishing.
- The physical universe: An introduction to astronomy, F. Shu, Mill Valley: University Science Books.
- Fundamentals of Astronomy (Fourth Edition), H. Karttunen *et al*. Springer.
- Astro Physics a modern perspective-K. S. Krishnasamy, (New Age International (P) Ltd, 2002)
- An introduction to Astrophysics - Baidyanath Basu, (Prentice-Hall of India Private limited, 2001).
- Textbook of Astronomy and Astrophysics with elements of cosmology, V. B. Bhatia, Narosa Publication.

Major Subject Syllabus

(Credit: Theory- 03; Practical- 01)

MAJ003 (Theory): Electricity and Magnetism

Electricity and Magnetism	
45 Lectures	**3 Credits**
Electric Field and Electric Potential	
Electric field; Electric field lines. Electric flux. Gauss Law, its applications to charge distributions with spherical, cylindrical and planar symmetry. Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. Potential and Electric Field of a dipole. Force and Torque on a dipole. Electrostatic energy of a system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Parallel-plate capacitor. Capacitance of an isolated conductor. Uniqueness theorem (statement). Method of Images and its application: A point charge placed in front of :(i) a plane infinite sheet and (ii) a Sphere.	
Dielectric Properties of Matter	
Electric Field ($\vec{E}$) in matter. Polarization ($\vec{P}$), Polarization of Charges. Electric susceptibility and dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector ($\vec{D}$). Relations between $\vec{E}$, $\vec{P}$ and $\vec{D}$. GaussLaw in dielectrics.	
Magnetic Field	
Magnetic force between current elements and definition ofMagnetic Field ($\vec{B}$). Biot-Savart's Law and its applications: straight wire and circular loop. Current loop as a magnetic dipole and its dipole moment (analogy with electric dipole). Ampere's circuital law and its application for (i) an infinite straight wire, (ii) infinite planar surface current, and(iii) solenoid. Properties of ($\vec{B}$) : curl and divergence of a vector. Vector Potential. Magnetic Force on (i) a point charge, (ii) a current carrying wire, (iii) between current elements. Torque on a current loop in a uniform magnetic field.	

Magnetic Properties of Matter

Magnetization vector ($\vec{M}$). Magnetic Intensity ($\vec{H}$). Magnetic susceptibility and permeability. Relation between $\vec{B}$, $\vec{H}$ and $\vec{M}$.

Electromagnetic Induction

Faraday's Law. Lenz's Law. Self-inductance and mutual inductance. Reciprocity theorem. Energy stored in a magnetic field. Introduction to Maxwell's equations. Charge conservation and displacement current.

Electrical Circuits

AC Circuits: Kirchhoff's laws for AC circuits. Complex reactance and impedance. Series LCR Circuit: (i) Resonance, (ii) Power Dissipation, (iii) Quality Factor, and (iv) Band width. Parallel LCR Circuit.

Network theorems

Ideal constant-voltage and constant-current sources. Network theorems: Thevenin theorem, Norton theorem, Superposition theorem, Maximum Power Transfer theorem. Applications to DC circuits.

Reference Books

- Electricity, Magnetism and Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw Hill Education.
- Electricity and Magnetism, E. M. Purcell, 1986, McGraw-Hill Education
- Introduction to Electrodynamics, D. J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
- Feynman Lectures,Vol.2, R. P. Feynman, and R. B. Leighton, and M. Sands, 2008, Pearson Education.
- Elements of Electromagnetics, M. N. O. Sadiku, 2010, Oxford University Press.
- Electricity and Magnetism, J. H. Fewkes and J. Yarwood, Vol.I, 1991, Oxford Univ. Press.

MAJ003 (Practical): Electricity and Magnetism Lab

Electricity and Magnetism	
	1 Credits

General topic

Use of Multi-meter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) testing electrical fuses**.**

List of Experiments

1. To study the charging and discharging characteristics of a capacitor using series DC C-R Circuit.
2. To determine an unknown Low Resistance using Potentiometer.
3. To determine an unknown Low Resistance using Carey Foster's Bridge.
4. To determine the resistance of a galvanometer using Thomson's method.
5. Measurement of field strength (B) and its variation in a solenoid (determine dB/dx)
6. To verify the Thevenin and Norton theorems.
7. To verify the Superposition, and Maximum power transfer theorems.
8. To study the AC L-R circuit, to draw the phase diagrams, to study the current voltage relationship across L and to study the variation of reactance of L with frequency and hence to find the inductance.
9. To study the AC C-R circuit, to draw the phase diagrams, to study the current voltage relationship across L and to study the variation of reactance of C with frequency and hence to find its loss factor.
10. To study the response curve of a series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor and (d) Band width.
11. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.

Reference Books

- Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
- A Text Book of Practical Physics, I. Prakash and Ramakrishna,11th Ed.,2011, Kitab Mahal.
- Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th Edition, Heinemann Educational Publishers.
- Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning.
- A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal, 1985, Vani Pub.

MAJ004 (Theory): Waves and Optics

Waves and Optics	
45 Lectures	**3 Credits**
Superposition of Collinear Harmonic oscillations	
Linearity and Superposition Principle. Superposition of two collinear oscillations having (i) equal frequencies and (ii) different frequencies (Beats).	
Superposition of two perpendicular Harmonic Oscillations	
Graphical and Analytical Methods. Lissajous figures with equal and unequal frequency and their uses.	
Wave Motion	
Planeand Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave velocities. Differential equation of a wave. Pressure of a longitudinal wave. Energy transport. Intensity of a wave.	
Superposition of Two Harmonic Waves	
Standing (Stationary) waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to position and time. Energy of vibrating string. Transfer of energy. Normal modes of Stretched strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal modes. Open and Closed Pipes. Superposition of N harmonic waves.	
Wave Optics	
Electromagnetic nature of light. Definition and properties of wavefront. Huygens Principle. Temporal and Spatial Coherence.	
Interference	
Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index.	

Interferometer

Michelson Interferometer :(i) Idea of form of fringes (No theory required), (ii) Determination of Wavelength,(iii) Wavelength Difference, (iv) Refractive Index, and (v) Visibility of Fringes.

Diffraction

Fraunhofer diffraction: Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating.

Fresnel Diffraction: Fresnel's assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light.

Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit, and a wire.

Reference Books

- Waves: Berkeley Physics Course, vol.3, F. Crawford, 2007, TataMcGraw-Hill.
- Fundamentals of Optics, F. A. Jenkins and H. E. White, 1981, McGrawHill.
- Principles of Optics, M. Born and E. Wolf, 7th edition, 1999, Pergamon Press.
- Optics, A.Ghatak, 2008, Tata McGraw Hill.
- The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
- The Physics of Waves and Oscillations, N. K. Bajaj, 1998, Tata McGraw Hill.
- Fundamental of Optics, A. Kumar, H. R. Gulati, and D. R. Khanna, 2011, R.Chand Publications.

MAJ004 (Practical): Wave and Optics Lab

Wave and Optics	
	1 Credits

List of Experiments

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2-□ law.
2. To investigate the motion of coupled oscillators.
3. To study Lissajous Figures.
4. Adjustment of a spectrometer by Schuster's method and to calibrate the spectrometer (D-λ curve) and hence determination of an unknown wavelength.
5. To determine the angle of a prism and hence to find out the refractive index of the material of a prism using sodium source.
6. To draw the μ-λ curve of the material of a prism using Hg/He/Ar source and determine the dispersive power and Cauchy constants.
7. To determine the wavelength of Sodium source using Michelson's interferometer.
8. To determine wavelength of Sodium light using Fresnel Biprism.
9. To determine wavelength of Sodium light using Newton's Rings.
10. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
11. To determine wavelength of (a) Na source and (b) spectral lines of Hg source using plane diffraction grating.
12. To determine dispersive power and resolving power of a plane diffraction grating.

Reference Books

- Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971,Asia Publishing House
- A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11th edition., 2011, Kitab Mahal
- Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publishers.
- A Laboratory Manual of Physics for undergraduate classes,D. P. Khandelwal, 1985, Vani Pub.

MAJ005 (Theory): Mathematical Physics-II

Mathematical Physics–II	
45 Lectures	**3 Credits**

Fourier Series

Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity.

Frobenius Method and Special Functions

Frobenius Method: Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Series solution to Legendre, Bessel, Hermite and Laguerre differential equations.

Special Functions: Properties of Legendre polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions $J_o(x), J_1(x)$and Orthogonality.

Special Integrals

Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).

Partial Differential Equations

Solutions to partial differential equations, using separation of variables: Laplace's equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. Diffusion Equation.

Reference Books

- Mathematical Methods for Physicists: G. B. Arfken, H. J. Weber, and F. E. Harris, 2005, Elsevier.
- Fourier Analysis by M. R. Spiegel, 2004, Tata McGrawHill.

- Mathematics for Physicists, S. M. Lea, 2004, Thomson Brooks/Cole.
- Differential Equations, G. F. Simmons, 2006, Tata McGrawHill.
- Partial Differential Equations for Scientists and Engineers, S.J. Farlow, 1993, Dover Pub.
- Engineering Mathematics, S. Pal and S.C.Bhunia,2015, Oxford University Press
- Mathematical methods for Scientists and Engineers, D. A. McQuarrie, 2003, Viva Books.
- Mathematical Physics, P. K. Chattopadhyay, 2014, New Academic Science.

MAJ005 (Practical): Mathematical Physics II Lab

Mathematical Physics II	
	1 Credits
Introduction to Numerical computation using *numpy* and *scipy*	
Introduction to the python *numpy* module. Arrays in *numpy*, array operations, array item selection, slicing, shaping arrays. Basic linear algebra using the *linalg* submodule. Introduction to online graph plotting using matplotlib. Introduction to the *scipy* module. Uses in optimization and solution of differential equations.	
Curve fitting, Least square fit, Goodness of fit, standard deviation (using *numpy* and *scipy*)	
Use Ohm's law to calculate Resistance, Hooke's law to calculate spring constant	
Solution of Linear system of equations, Diagonalization of matrices, Inverse of a matrix, Eigen vectors, Eigenvalue problems (using *numpy* and *scipy*)	
Solution of mesh equations of electric circuits having 3meshes. Solution of coupled spring mass systems with 3 masses.	
Generation of Special functions using User defined functions	
Generating and plotting Legendre Polynomials Generating and plotting Bessel function	
Solution of First order and second order Ordinary Differential equation using *numpy*and *scipy*	

First order differential equations:

1. Radioactive decay
2. Current in RC, LC circuits with DC source
3. Newton's law of cooling
4. Classical equations of motion, Second order Differential Equation
5. Harmonic oscillator (no friction)
6. Damped Harmonic oscillator, Overdamped and Critically damped cases.
7. Forced Harmonic oscillator
8. Transient andSteady state solution
9. Apply above to LCR circuits also
10. Solve

$$\square^2 \frac{\square^2 \square}{\square^2 \square} - 4\square(1+\square)\frac{\square\square}{\square\square} + 2(1+\square)\square = \square^3$$

with the boundary conditions: at $\square = 1$, $\square = 0.5\square^2$, $\frac{\square\square}{\square\square} = -1.5\square^2 - 0.5$, in the range $1 \leq \square \leq 3$. Plot $\square$ and $\frac{\square\square}{\square\square}$ against $\square$ in the given range in the same graph.

Reference Books

- Mathematical Methods for Physics and Engineers, K. F. Riley, M. P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
- Complex Variables, A. S. Fokas and M. J. Ablowitz, 8th edition, 2011, Cambridge Univ. Press
- Numpy beginner's guide, I. Alba, 2015, Packt Publishing
- Computational Physics, D.Walker, 1st edition, 2015, Scientific International Pvt. Ltd.
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. V. Wouwer, P. Saucez, and C. V. Fernandez, 2014, Springer

MAJ006 (Theory): Thermal Physics

Thermal Physics	
45 Lectures	**3 Credits**

Kinetic Theory of Gases

Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas (No proof required). Mean RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases.

Molecular Collisions: Mean Free Path. Collision Probability. Estimates of Mean Free Path.

Real Gases : Behaviour of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO_2 Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waals Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. P-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule- Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule- Thomson Cooling.

Introduction to Thermodynamics

Zeroth and First Law of Thermodynamics: Extensive and intensive thermodynamical Variables, Thermodynamical Equilibrium, Zeroth Law of thermodynamics and concept of Temperature, Concept of Work and Heat, State Functions, First Law of thermodynamics and its differential form, Internal Energy, First Law and various processes, Applications of First Law: General Relation between $C_P$and C_V, Work Done during Isothermal and Adiabatic Processes.

2^{nd} Law of Thermodynamics: Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine and efficiency. Refrigerator and coefficient of performance, 2^{nd} Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their equivalence.

Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Temperature–Entropy diagrams for a given Cycle. Third Law of

Thermodynamics. Unattainability of absolute Zero.

Thermodynamic Potentials

Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations

Maxwell's Thermodynamic Relations

Derivations and applications of Maxwell's Relations, Maxwell's Relations:

(a) Clausius-Clapeyron equation,

(b) Expression of □□ − □□,

(c) TdS Equations,

(d) Joule-Kelvin coefficient for Ideal and Van der Waal Gases,

(e) Energy equations,

(f) Change of Temperature during Adiabatic Process.

Reference Books

- Heat and Thermodynamics, M. W. Zemanskyand R.Dittman, 1981, McGrawHill.
- Thermal Physics, S. Garg, R. Bansal, and Ghosh, 2nd edition, 1993, Tata McGrawHill
- Modern Thermodynamics with Statistical Mechanics, C. S. Helrich, 2009, Springer.
- Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Sears and Salinger, 1988, Narosa.
- Concepts in Thermal Physics, S. J. Blundell and K. M. Blundell, 2nd edition., 2012, Oxford University Press
- Thermodynamics and an introduction to thermostatistics, H. B. Callen, 1985, Wiley.
- Thermal Physics, A. Kumar and S. P. Taneja, 2014, R. Chand Publications.

MAJ006 (Practical): Thermal Physics Lab

Thermal Physics Lab	
	1 Credits

List of Experiments

1. To determine mechanical equivalent of Heat (J) by Callender and Barne's constant flow method.
2. To determine the coefficient of thermal conductivity of Cu using Searle's apparatus.
3. To determine the coefficient of thermal conductivity of Cu using Angstrom's Method.
4. To determine the coefficient of thermal conductivity of a bad conductor using Lee and Charlton's disc method.
5. Determination of the thermal conductivity of glass in the form of a tube.
6. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
7. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
8. To calibrate a thermocouple to measure temperature in a specified Range using (a) Null Method, (b) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature
9. To measure the coefficient of thermal linear expansibility of a rod using optical lever.
10. To determine the temperature coefficient of resistance of copper using metre bridge.

Reference Books

- Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House
- A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11th edition,2011, Kitab Mahal
- Advanced level Physics Practicals, M.Nelson and J. M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publishers
- A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal, 1985, Vani Pub.

MAJ007 (Theory): Quantum Mechanics

Quantum Mechanics	
45 Lectures	**3 Credits**
Introduction to Quantum Mechanics	
Blackbody Radiation: Rayleigh-Jeans law (statement only), Wein's distribution law (Statement only) and Planck's radiation law; Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Wave amplitude and wave functions.	
Uncertainty principle, introduction to operator physics and Schrödinger equation	
Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from Wave Packets impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle- application to virtual particles and range of an interaction. Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Momentum and Energy operators; commutator algebra; Schrödinger equation for non-relativistic particles; stationary states; physical interpretation of a wave function, probabilities and normalisation; Probability and probability current densities in one dimension.	
Simple applications of Schrödinger equation	
One dimensional infinitely rigid box-energy eigenvalues and eigenfunctions, normalisation; Quantum dot as example; Quantum mechanical scattering and tunnelling in one dimension - across a step potential, rectangular potential barrier, and square well. Linear harmonic oscillator; Zero-point energy and uncertainty principle.	

Reference Books

- Concepts of Modern Physics, A. Beiser, 2002, McGrawHill.
- Introduction to Modern Physics, F. K. Richtmyer, E. H. Kennard, and J. N. Cooper, 2002, Tata McGraw Hill
- Introduction to Quantum Mechanics, D. J. Griffith, 2005, Pearson Education.
- Physics for scientists and Engineers with ModernPhysics, Jewett and Serway, 2010, Cengage Learning.
- Modern Physics, G. Kaur and G. R. Pickrell, 2014, McGraw Hill
- Quantum Mechanics: Theory and Applications, A.K.Ghatak and S.Lokanathan, 2004, Macmillan
- Modern Physics, J. R. Taylor, C. D. Zafiratos, and M. A. Dubson, 2004, PHI Learning.
- Theory and Problems of Modern Physics, Schaum's outline, R. Gautreau and W. Savin, 2nd edition, Tata McGrawHill Publishing Co. Ltd.
- Quantum Physics, Berkeley Physics, Vol.4. E. H. Wichman, 1971, TataMcGrawHill Co.
- Basic ideas and concepts in Nuclear Physics, K. Heyde, 3rd edition, Institute of Physics Pub.
- Six Ideas that Shaped Physics: Unit-Q, Particles Behave like Waves, T.A.Moore, 2003, McGraw Hill

MAJ007 (Practical): Quantum Mechanics Lab

Quantum Mechanics Lab	
	1 Credits

List of Experiments

1. Measurement of Planck's constant using blackbody radiation and photo-detector
2. Photo-electriceffect: photocurrent versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
3. To determine the work function of material of filament of directly heated vacuum diode.
4. To determine the Planck's constant using LEDs of at least 4 differentcolours.
5. To determine the wavelength of the H-alpha emission line of Hydrogen atom.
6. To determine the ionisation potential of mercury.
7. To determine the absorption lines in the rotational spectrum of Iodine vapour.
8. To determine the value of $\frac{e}{m}$by (a) Magnetic focusing or (b) Bar magnet.
9. To set up the Millikan oil drop experiment and determine the charge of an electron.
10. To show the tunnelling effect in a tunnel diode using I-V characteristics.
11. To determine the wavelengthof a laser source using diffraction from a single slit.
12. To determine the wavelength of a LASER source using diffraction from double slits.
13. To determine (a) wavelength and (b) angular spread of He-Ne laser using plane diffraction grating

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H. T. Worsnop, 1971, Asia Publishing House
- Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th edition, reprinted1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11th edition, 2011, Kitab Mahal

MAJ008 (Theory+Tutorial): Classical Mechanics –I

Classical Mechanics	
45 Lectures (Theory)	Theory: 3 Credit Tutorial: 1 Credit

Classical Mechanics

Work, Energy and Collisions: Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Qualitative study of 1D motion from potential energy curves. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work and potential energy. Work done by non-conservative forces. Law of Conservation of Energy. Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames.

Constraints: Degrees of freedom, constraints, holonomic and nonholonomic constraints with examples, generalized coordinates.

Principle of Virtual Work: Virtual displacement and virtual work, principle of virtual work, D'Alembert's principle, simple applications, generalized force and generalized moments.

Lagrangian Formalism: Lagrange's equations of motion from D'Alembert's principle, application to simple systems, canonically conjugate momenta, cyclic coordinates.

Variational Principle: Functionals. Basic ideas of functionals. Extremization of action as a basic principle in mechanics, variational calculus, Lagrange's equations from the variational principle, Applications to simple systems.

Hamiltonian Formalism: The Hamiltonian and its physical significance, Hamilton's equations of motion and application to simple systems. Applications to simple systems.

Special Theory of Relativity

Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum.

Reference Books
► Classical Mechanics, H. Goldstein, C. P. Poole, and J. L. Safko, 3rd edition. 2002, Pearson Education. ► Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon. ► The Feynman Lectures on Physics, R. P. Feynman, Vol. 1 (2nd ed.), 2005, Addison-Wesley. ► Classical Mechanics: Systems of Particles and Hamiltonian Dynamics, W. Greiner, 2009, Springer ► An Introduction to Mechanics, D. Kleppner and R. Kolenkow, 1973, McGraw Hill

MAJ009 (Theory): Analog Electronics

Analog Electronics	
45 Lectures	**3 Credits**
Semiconductor Diodes	
Semiconductors: p and n type . Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. Barrier Formation in p-njunction diodes. Static and dynamic resistance. Current flow mechanism in forward and reverse biased diode. Drift velocity. Derivation for barrier potential, Barrier width and current for step junction. Current flow mechanism in forward and reverse biased diode.	
Two-terminal Devices and their Applications	
Zener diode and Voltage regulation. Principle and structure of (a) Light Emitting Diode (LED), (b) Photo diode, and (c) Solar Cell.	
Bipolar Junction transistors	
Transistors: n-p-n and p-n-p. Characteristics of CB, CE and CC Configurations. Current gains α and β Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions.	
Field Effect transistors	
JFET and MOSFET :Basic principle of operations only	
Amplifiers	

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers. Frequency response of a CE amplifier.

Coupled Amplifier: Two-stage RC-coupled amplifier.

Feedback in Amplifiers: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley and Colpitts oscillators.

Operational Amplifiers (OPAMP): Black Box approach; Characteristics of an Ideal and Practical OPAMP (IC 741), Open-loop and Closed-loop gain, Frequency Response, CMRR, Slew Rate and concept of virtual ground.

Applications of OPAMP: Linear - (i) Inverting and non-inverting amplifiers, (ii) Adder, (iii) Subtractor, (iv) Differentiator, (v) Integrator, (vi) Log amplifier, (vii) Zero crossing detector and (viii) Wein bridge oscillator.

Nonlinear – (i) inverting and non-inverting comparators, (ii) Schmidt triggers.

Conversion: Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation).

Reference Books

- Integrated Electronics, J. Millman and C. C. Halkias, 1991, Tata Mc-GrawHill.
- Electronics: Fundamentals and Applications, J. D. Ryder, 2004, Prentice Hall.
- Solid State Electronic Devices, B. G. Streetman and S. K. Banerjee, 6th edition, 2009, PHI Learning
- Electronic Devices andcircuits, S. Salivahanan and N. S. Kumar, 3rd edition, 2012, Tata Mc-GrawHill
- OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
- Microelectronic circuits, A. S.Sedra, K. C. Smith, and A. N. Chandorkar, 2014, 6th edition, Oxford University Press.
- Electronic circuits: Handbook of design and applications, U. Tietze, and C. Schenk, 2008, Springer
- Semiconductor Devices: Physics and Technology, S. M. Sze, 2nd edition, 2002, Wiley India
- Microelectronic Circuits, M. H. Rashid, 2nd edition, Cengage Learning
- Electronic Devices,T. L. Floyd, 7th edition, 2008, Pearson India

MAJ009 (Practical): Analog Electronics Lab

Analog Electronics Lab	
	1 Credits

List of Experiments

1. To study V-I characteristics of p-n junction diodes, and Light emitting diodes.
2. To study the V-Icharacteristics of a Zener diode and its use as voltage regulator.
3. Study of V-I and power curves of solar cells, and find maximum power point and efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To study the various biasing configurations of BJT for normal class A operation.
6. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
7. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
8. To design a Wien bridge oscillator for a given frequency using an OPAMP.
9. To design a phase shift oscillator of given specifications using BJT.
10. To study the Colpitt's oscillator.
11. To design a digital to analog converter (DAC) of given specifications.
12. To study the analog to digital convertor (ADC) IC.
13. To design an inverting amplifier using OPAMP(741,351) for dc voltage of given gain
14. To design inverting amplifier using OPAMP(741,351) and study its frequency response
15. To design non-inverting amplifier using OPAMP(741,351) and study its frequency response
16. To study the zero-crossing detector and comparator using an OPAMP.
17. To add two dc voltages using OPAMPin inverting and non-inverting mode
18. To design a precision Differential amplifier of given I/O specification using OPAMP.
19. To investigate the use of an OPAMPas an Integrator.
20. To investigate the use of an OPAMPas a Differentiator.
21. To design a circuit to simulate the solution of a 1st/2nd order differential equation.

Reference Books
► Basic Electronics: A text lab manual, P. B. Zbar, A. P. Malvino, and M. A. Miller, 1994, Mc-GrawHill. ► OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall. ► Electronic Principle, A. Malvino, 2008, Tata Mc-GrawHill. ► Electronic Devices and circuit Theory, R. L. Boylestad and L. D. Nashelsky, 2009, Pearson

MAJ0010 (Theory): Mathematical Physics III

Mathematical Physics–III	
45 Lecture	**3 Credits**
Dirac Delta function	
Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function. Dirac delta function in three dimensions.	
Fourier Transforms	
Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train. Representation of Dirac delta functions as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations.	
Matrices	
Addition and Multiplication of Matrices. Null Matrices. Diagonal Matrix, Scalar and Unit Matrices. Upper-Triangular and Lower-Triangular Matrices. Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew-Hermitian Matrices. Singular and Non-Singular matrices. Orthogonal and Unitary Matrices. Trace of a Matrix. Inner Product Eigen-values and Eigenvectors, Cayley- Hamilton Theorem. Diagonalization of Matrices. Solutions of Coupled Linear Ordinary Differential Equations. Functions of a Matrix.	

Probability Theory

Independent random variables: Probability distribution functions; binomial, Gaussian, and Poisson, with examples. Mean and variance. Fundamental Probability Theorems. Conditional Probability, Bayes' Theorem, hypothesis testing , Repeated Trials, Binomial and Multinomial expansions. Random Variables and probability distributions, Expectation and Variance, Special Probability distributions: The binomial distribution, The Poisson distribution, Continuous distribution: The Gaussian (or normal) distribution, The principle of least squares.

Reference Books

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd edition, 2006, Cambridge University Press
- Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
- Mathematical Methods for Physicists: G. B. Arfken, H. J. Weber, and F. E. Harris, 2005, Elsevier.
- Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw Hill.
- Mathematics for Physicists, S. M. Lea, 2004, Thomson Brooks/Cole.
- Differential Equations, G.F. Simmons, 2006, Tata McGraw Hill.
- Partial Differential Equations for Scientists and Engineers, S.J. Farlow, 1993, Dover Pub.
- Engineering Mathematics, S. Pal and S.C.Bhunia,2015, Oxford University Press
- Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Books.
- Mathematical Physics, P. K. Chattopadhyay, 2014, New Academic Science.

MAJ010 (Practical): Mathematical Physics III Lab

Mathematical Physics III Lab	1 credit

Practicals: Using *Numpy/ Scipy*. Plotting should be done wherever possible.

1. To compute forward and inverse Fourier transform of a given signal using FFT. Determination of frequencies in the signal by plotting power spectral density.

2. To evaluate Fourier coefficients of given functions.

3. Dirac Delta Function: Evaluate

$$\frac{1}{\sqrt{2\pi\sigma^2}} \int e^{\frac{-(x-2)^2}{2\sigma^2}} (x+3)\,\mathrm{d}x\,,$$

   for σ=1, 0.1, and 0.01. and find the limiting value of the integralas $\sigma \to 0$. Verify using Dirac Delta function.

4. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two). Perform a least square fitting of the data without giving weightage to error.

5. Evaluation and plotting of □□(□) and □□(□) for integer values of □, verification of orthogonality properties of Legendre function and Bessel function of the first kind.

6. Solve the differential equations of the following type and plot the solutions.

   (a) $\frac{dy}{dx} = e^{-x}$, with $y = 0$ at $x = 0$
   (b) $\frac{dy}{dx} + e^{-x}y = x^2$, with $y = 0$ at $x = 0$
   (c) $\frac{d^2y}{dt^2} + 2\frac{dy}{dt} = -y$, with $y = 0$ and $y' = 1$ at $t = 0$
   (d) $\frac{d^2y}{dt^2} + e^{-t}\frac{dy}{dt} = -y$, with $y = 0$ and $y' = 1$ at $t = 0$

MAJ011 (Theory+Tutorial): Atomic Physics

Atomic Physics	
45 Lectures (Theory)	Theory: 3 Credit, Tutorial: 1 Credit

Angular Momentum

Angular momentum operator in Cartesian coordinates and its representation in spherical polar coordinates; Commutation relations of angular momentum operator; Eigenvalues and eigenfunctions of L^2.

Quantum theory of Hydrogen-like atoms

Time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator and quantum numbers; Radial wave functions from Frobenius method; shapes of the probability densities for ground and first excited states; Orbital angular momentum quantum numbers l and m; s, p, d-shells.

Atoms in Electric and Magnetic Fields

Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton.

Atoms in External Magnetic Fields

Normal and Anomalous Zeeman Effect. Paschen-Back and Stark Effect (Qualitative Discussion only).

Many electron atoms

Pauli's Exclusion Principle. Symmetric and Antisymmetric Wave Functions. Periodic table. Fine structure.Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum.

Vector Model. Spin-orbit coupling in atoms: L-S and J-J couplings. Hund's Rule. Term symbols. Spectra of Hydrogen and Alkali Atoms (Na etc.).

LASER

Einstein's *A* and *B* coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. Basic lasing.

Reference Books

- A Textbook of Quantum Mechanics, P. M. Mathews and K. Venkatesan, 2nd edition, 2010, McGraw Hill
- Quantum Mechanics, R. Eisberg and R. Resnick, 2nd edition, 2002, Wiley.
- Quantum Mechanics, L. I. Schiff, 3rd edition, 2010, Tata McGraw Hill.
- Quantum Mechanics, G. Aruldhas, 2nd edition, 2002, PHI Learning of India.
- Quantum Mechanics, B. C. Reed, 2008, Jones and Bartlett Learning.
- Quantum Mechanics: Foundations and Applications, A. Bohm, 3rd edition, 1993, Springer
- Quantum Mechanics for Scientists andEngineers, D. A. B. Miller, 2008, Cambridge University Press
- Quantum Mechanics, E. Merzbacher, 2004, John Wiley and SonsInc.
- Introduction to Quantum Mechanics, D. J. Griffith, 2nd edition, 2005, Pearson Education
- QuantumMechanics, W. Greiner, 4th edition, 2001, Springer

MAJ012 (Theory): Solid State Physics

Solid State Physics	
45 Lectures	**3 Credits**
Crystal Structure	
Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor.	
Elementary Lattice Dynamics	
Lattice Vibrations and Phonons: Linear Monatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law	
Magnetic Properties of Matter	
Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of Dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of (B-H) Curve. Hysteresis and Energy Loss.	
Dielectric Properties of Materials	
Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius-Mossotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeier relations. Langevin-Debye equation. Complex Dielectric Constant, Ferroelectric Properties of Materials: Structural phase transition, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.	
Elementary band theory	
Kronig-Penny model. Band Gap. Conductor, Semiconductor (p and n type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of electrical conductivity (04 probe method) and Hall coefficient.	
Superconductivity	

Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation)

Reference Books

- Introduction to Solid State Physics, C. Kittel, 8th edition, 2004,Wiley India Pvt. Ltd.
- Elements of Solid State Physics, J. P. Srivastava, 4th edition, 2015, PrenticeHall of India
- Introduction to Solids, L. V. Azaroff, 2004, Tata McGraw Hill
- Solid State Physics, N. W. Ashcroft and N. D. Mermin, 1976, Cengage Learning
- Solid-State Physics, H. Ibach and H. Luth, 2009, Springer
- Solid State Physics, R. John, 2014, McGraw Hill
- Elementary Solid State Physics,M. A. Omar, 1999, Pearson India
- Solid State Physics, M. A. Wahab, 2011, Narosa Publications

MAJ012 (Practical): Solid State Physics Lab

Solid State Physics Lab	
	1 Credits

List of Experiments

1. Measurement of susceptibility of paramagnetic solution (Quinck's Tube Method)
2. To measure the Magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the Dielectric Constant of a dielectric Materials with frequency
5. To study the PE Hysteresis loop of a Ferroelectric Crystal.
6. To draw the BH curve of Fe using Solenoid and determine energy loss from Hysteresis.
7. To determine the energy gap of a semiconductor using a pn junction diode.
8. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 ^{o} C) and to determine its band gap.
9. To determine the Hall coefficient of a semiconductor sample.

Reference Books

- Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th edition, reprinted1985, Heinemann Educational Publishers.
- A TextBook of Practical Physics, I. Prakash and Ramakrishna, 11th edition, 2011, Kitab Mahal
- Elements of Solid State Physics, J. P. Srivastava, 2nd edition, 2006, PrenticeHall of India.

MAJ013 (Theory): Electromagnetic Theory

Electromagnetic Theory	
45 Lectures	**3 Credits**
Maxwell's Equations	
Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic(EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density.	
EM Wave Propagation in Unbounded Media	
Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere.	
EM Wave in Bounded Media	

Boundary conditions at a plane interface between two media. Reflection and Refraction of plane waves at plane interface between two dielectric media- Laws of Reflection and Refraction. Fresnel's Formula for perpendicular and parallel polarization cases, Brewster's law. Reflection and Transmission coefficients. Total Internal Reflection, evanescent waves. Metallic reflection (normal Incidence)

Polarization of Electromagnetic Waves

Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary and extraordinary refractive indices. Production and detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light

Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter.

Reference Books

- Introduction to Electrodynamics, D. J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
- Optics, E.Hecht, 2016, Pearson.
- Elements of Electromagnetics, M. N. O. Sadiku, 2001, Oxford University Press.
- Introduction to Electromagnetic Theory, T. L. Chow,2 006, Jones & Bartlett Learning
- Fundamentals of Electromagnetics, M. A. W. Miah, 1982, Tata McGraw Hill
- Electromagnetic field Theory, R. S. Kshetrimayun, 2012, Cengage Learning
- Engineering Electromagnetic, W. H. Hayt, 8th edition, 2012, McGraw Hill.
- Electromagnetic Field Theory for Engineers and Physicists, G. Lehner, 2010, Springer
- Electromagnetic Fields and Waves, P. Lorrain and D. Corson, 1970, W. H. Freeman & Co.
- Electromagnetics, J. A. Edminster, SchaumSeries, 2006, Tata McGraw Hill.
- Electromagnetic field theory fundamentals, B. Guru and Hiziroglu, 2004, Cambridge University Press

MAJ013 (Practical): Electromagnetic Theory Lab

Electromagnetic Theory Lab	
	1 Credits

List of Experiments

1. To verify the Malus law for plane polarized light.
2. To determine the specific rotation of sugar solution using a Polarimeter.
3. To analyze elliptically polarized Light using a Babinet's compensator.
4. To study dependence of radiation on angle for a simple dipole antenna.
5. To determine the wavelength and velocity of ultrasonic waves in a liquid(KeroseneOil,Xylene, etc.) by studying the diffraction through ultrasonic grating.
6. To study the reflection, refraction of microwaves
7. To study Polarization and Double Slit Interference in Microwaves.
8. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
9. To determine the refractive Index of (a) glass and (b) a liquid by total internal reflection using a Gaussian eyepiece.
10. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
11. To verify the Stefan's law of radiation and determine Stefan constant.
12. To determine the Boltzmann constant using I-V characteristics of a p-njunction diode.

Reference Books

- Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th edition, reprinted1985, Heinemann Educational Publishers
- A TextBook of Practical Physics, I. Prakash and Ramakrishna, 11th edition, 2011, Kitab Mahal
- Electromagnetic Field Theory for Engineers and Physicists, G. Lehner, 2010, Springer

MAJ014 (Theory + Tutorial): Statistical Mechanics

Statistical Mechanics	
(Theory-3 credit; Tutorial-1 credit)	
Classical Statistical Mechanics	
Macrostate and Microstate, Elementary Concept of Ensemble, Microcanonical ensemble, Phase Space, Entropy and Thermodynamic Probability, Canonical ensemble, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur-Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature. Grand canonical ensemble and chemical potential.	
Quantum Statistics	
Identical particles and symmetry requirements, derivation of Maxwell-Boltzmann, Bose-Einstein, Fermi-Dirac statistics as the most probable distributions, Classical limit of quantum mechanics	
Bose-Einstein Statistics	
Bose-Einstein distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law.	
Fermi-Dirac Statistics:	
Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit.	

Reference Books

- Statistical and ThermalPhysics, S. Lokanathan and R. S. Gambhir, 1991, Prentice Hall
- Thermodynamics,KineticTheory, and Statistical Thermodynamics, F. W. Sears and G. L. Salinger, 1986, Narosa.
- Modern Thermodynamics with Statistical Mechanics, C. S. Helrich, 2009, Springer
- An Introduction to Statistical Mechanics and Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press
- Statistical Mechanics–an elementary outline, A. Lahiri, 2008, Universities Press
- Statistical Mechanics, R. K. Pathria, and B.Heinemann,1996,Oxford University Press.
- Statistical Physics, Berkeley Physics Course, F.Reif, 2008, Tata McGrawHill

MAJ015 (Theory): Digital Electronics

Digital Electronics	
45 Lectures	**3 Credits**

Integrated Circuits (ICs)

Active and Passive components of circuits. Discrete components. Wafer. Chip. Advantages and drawbacks ofICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital lCs.

Digital Circuits

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers.

Boolean algebra

De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (a) Sum of Products Method and (b) Karnaugh Map.

Data processing circuits

Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.

Circuits

Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half and Full Subtractors, 4-bit binary Adder/Subtractor.

Sequential Circuits: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop.

Timers

IC555: block diagram and applications: A stable multivibrator and Mono stable multivibrator.

Shift registers

Serial-InSerial-Out (SISO), Serial-InParallel-Out, Parallel-InSerial-Out and Parallel-InParallel-Out (PIPO) Shift Registers(only up to 4 bits).

Counters (4 bits)

Ring counter. Asynchronous counters, Decade counter. Synchronous counter.

Reference Books

- Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha,7th Ed.,2011,Tata McGraw Hill
- Fundamentals of Digital Circuits, A. Kumar ,2nd edition, 2009, PHI Learning Pvt. Ltd.
- Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
- Digital Electronics, G. K. Kharate, 2010, Oxford University Press
- Digital Systems: Principles and Applications, R. J. Tocci and N. S. Widmer, 2001, PHI Learning
- Logic circuit design, S. P. Vingron, 2012, Springer.
- Digital Electronics, S.Ghoshal, 2012, Cengage Learning.
- Digital Electronics, S. K. Mandal, 2010, 1st edition, McGraw Hill
- Microprocessor Architecture Programming and applications with 8085, 2002, R.S. Gaonkar, Prentice Hall

MAJ015 (Practical): Digital Electronics Lab

Digital Electronics Lab	
	1 Credits

List of Experiments

1. To measure (a)Voltage,and (b) Time period of a periodic waveform using CRO.
2. To test Diode and Transistor using a Multimeter.
3. To design a switch (NOT gate) using a transistor.
4. To verify and design AND, OR, NOT, and XOR gates using NAND gates.
5. To design a combinational logic system for a specified Truth Table.
6. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
7. To minimize a given logic circuit.
8. Half Adder, Full Adder, and 4-bit binary Adder.
9. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
10. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
11. To build JK Master-slave flip-flop using Flip-Flop ICs
12. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagrams.
13. To make a 4-bit Shift Register (serial and parallel) using D-type/ JK Flip-Flop ICs.
14. To design an Astablemultivibrator of given specifications using 555 Timer.
15. To design a Monostable multivibrator of given specifications using 555 Timer.

Reference Books

- Modern Digital Electronics, R. P. Jain, 4th edition, 2010, Tata McGraw Hill.
- Basic Electronics: A text lab manual, P. B. Zbar, A. P. Malvino, and M. A. Miller, 1994, McGraw Hill.

MAJ016 (Theory + Tutorial): Nuclear and Particle Physics

Nuclear and Particle Physics	
45 Lectures (Theory)	**(Theory-3 credit; Tutorial-1 credit)**
General Properties of Nuclei	
Constituents of nucleus and their intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, $\frac{BE}{A} vrs. A$ plot, angular momentum, parity, magnetic moment, electric moments, nuclear excited states.	
Nuclear Models	
Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate Fermi gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force.	
Radioactive decay	
(a) Alpha decay: basics of α-decay processes, theory of α- emission, Gamow factor, Geiger-Nuttall law, α- decay spectroscopy. (b) β-decay: energy kinematics for β-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission and kinematics, internal conversion.	
Nuclear Reactions	
Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct reaction, resonance reaction, Coulomb scattering (Rutherford scattering).	
Interaction of Nuclear Radiation with matter	
Energy loss due to ionization (Bethe-Bloch formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, pair production, neutron interaction with matter.	
Detector for Nuclear Radiations	

GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (*Si* and *Ge*) for charge particle and photon detection (*concept of charge carrier and mobility*).

Particle Accelerators

Linear accelerator, Cyclotron, Synchrotrons.

Particle Physics

Particle interactions; basic features, types of particles and their families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, colour quantum number and gluons.

Reference Books

- Introductory Nuclear Physics, K. S. Krane, 2008, Wiley India Pvt. Ltd.
- Concepts of nuclear physics by B. L. Cohen, 1998, Tata Mcgraw Hill.
- Introduction to the physics of nuclei and particles, R. A. Dunlap, 2004, Thomson Asia, 2004.
- Introduction to High Energy Physics, D. H. Perkins, Cambridge Univ. Press
- Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
- Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
- Basic ideas and concepts in Nuclear Physics-An Introductory Approach, K.Heyde, 2004, IOP-Institute of Physics Publishing.
- Radiation detection and measurement, G. F. Knoll, 2000, John Wiley & Sons.
- Physics and Engineering of Radiation Detection, S. N. Ahmed, 2007, Academic Press, Elsevier..
- Theoretical Nuclear Physics, J. M. Blatt and V. F. Weisskopf, 1991, Dover Pub. Inc.

MAJ017 (Theory + Tutorial): Mathematical Physics IV

Mathematical Physics IV	
45 Lectures (Theory)	**(Theory-3 credit; Tutorial-1 credit)**

Complex Analysis

Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected regions. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integrals.

Laplace Transform

Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along an infinite bar using Laplace transform.

Tensor Analysis

Cartesian Tensor: Transformation of Coordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Invariant Tensors: Kronecker and Alternating Tensors. Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors: Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector Identities. Tensorial Formulation of Analytical Solid Geometry: Equation of a Line. Angle Between Lines. Projection of a Line on another Line. Condition for Two Lines to be Coplanar. Foot of the Perpendicular from a Point on a Line. Rotation Tensor (No Derivation). Isotropic Tensors.

Tensorial Character of Physical Quantities.

General Tensor: Transformation of Coordinates. Minkowski Space. Contravariant and Covariant Vectors. Contravariant, Covariant and Mixed Tensors. KroneckerDelta. Permutation Tensors.

Algebra of Tensors: Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Antisymmetric Tensors. Metric Tensor.

Reference Books

- Mathematical Tools for Physics, J. Nearing, 2010, Dover Publications
- Mathematical Methods for Physicists, G. B. Arfken, H. J. Weber, and F. E. Harris, 1970, Elsevier.
- Modern Mathematical Methods for Physicists and Engineers, C. D. Cantrell, 2011, Cambridge University Press
- Introduction to Matrices and Linear Transformations, D. T. Finkbeiner, 1978, Dover Pub.
- Linear Algebra, W. Cheney, E. W. Cheney, andD. R. Kincaid ,2012, Jones & Bartlett Learning
- Mathematics for Physicists, S. M. Lea, 2004, Thomson Brooks/Cole
- Mathematical Methods for Physicists andEngineers, K. F. Riley, M. P. Hobson, and S. J. Bence, 3rd edition., 2006, Cambridge University Press
- Mathematical Methods for Physicists: A Concise Introduction: T. L. Chow, 2000, Cambridge Univ. Press.
- Elements of Group Theory for Physicists, A. W. Joshi, 1997, John Wiley.
- Group Theory and its Applications to Physical Problems, Morton Hamermesh, 1989, Dover Publication
- Introduction to Mathematical Physics: Methods and Concepts, C. W. Wong, 2012, Oxford University Press
- Introduction to Mathematical Probability, J. V. Uspensky, 1937, McGrawHill.

MAJ018 (Theory + Tutorial): Classical Mechanics II

Classical Mechanics II	
45 Lectures (Theory)	**(Theory-3 credit; Tutorial-1 credit)**

Symmetry

Integrals of motion, Symmetry and conservation principles in classical mechanics.

Small Amplitude Oscillations

Stable and unstable equilibrium, General case of coupled oscillations, General theory of small oscillations, Eigenvectors and Eigen frequencies, Orthogonality of eigenvectors, normal coordinates, Molecular vibrations as example, Loaded string.

Canonical Transformation

Canonical transformations, Generating functions, conditions for canonical transformation, Poisson brackets, Poisson theorem, Canonical transformation in terms of Poisson bracket, Jacobian Identity, Lagrange bracket,Hamilton-Jacobi theorem, Liouville's theorem.

Fluid Mechanics

Definition of a fluid: shear stress; concept of fluid element or fluid parcel; Fluid properties; Kinematics of Moving Fluids; stream, path and streak lines; Idea of compressible and incompressible fluids, Equation of continuity; laminar and turbulent flow (qualitative discussions), Reynold's number. Euler's Equation. Navier-Stokes' equation (no derivation) and its significance. Bernoulli's Theorem and its applications, Torricelli's theorem.

Reference Books

- Classical Mechanics, H. Goldstein, C. P. Poole, and J. L. Safko, 3rd edition, 2002, Pearson Education.
- Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
- Classical Electrodynamics, J. D. Jackson, 3rd edition,1998, Wiley.
- The Classical Theory of Fields, L. D. Landau and E.M Lifshitz, 4th edition, 2003, Elsevier.
- Introduction to Electrodynamics, D. J. Griffiths, 2012, Pearson Education.
- Classical Mechanics, P. S. Joag and N. C. Rana, 1st edition, McGraw Hill.
- Classical Mechanics, R. D. Gregory, 2015, Cambridge University Press.
- Classical Mechanics: An introduction, D. Strauch, 2009, Springer.
- Solved Problems in classical Mechanics, O. L. Delange and J. Pierrus, 2010, Oxford Press

MAJ019 (Theory): Computational Physics

Computational Physics	
45 Lectures	**3 Credits**

Errors in Numerical Methods

Different types of errors, Floating point representations of numbers, Errors in floating point arithmetic, Absolute, relative and percentage errors.

Interpolation and data fitting

Newton's forward and backward interpolation, Lagrange interpolation. Regression, Linear least square fitting, applications.

Root Finding methods

Bisection Method, Newton-Raphson method, applications.

System of Linear Equations

Gauss Jordan Method, applications.

Numerical Quadrature

General quadrature formula, Trapezoidal rule, Simpson's 1/3 rule, applications.

Ordinary Differential Equation

Solving 1^{st} order and 2^{nd} order ODEs, Euler method, Runge-Kutta methods (RK2 and RK4), and applications.

Partial Differential Equation

Solution of PDE using finite difference approximations, Forward-in-time and centered-in-space scheme, Boundary conditions: Dirichlet and Neumann condition, applications.

Monte-Carlo Methods

Generation of random numbers using Monte Carlo methods.

MAJ019 (Practical): Computational Physics Lab

Computational Physics Lab	
	1 Credits

(**The paper gives a hands on training to the students to solve physical problems making use of numerical models which can be solved further by the computer programming. The programs should be written using core Python functionalities, avoiding using numerical and scientific modules like *Numpy* and *Scipy* as much as possible**.)

1. Solving 1st Order and 2nd Order ODEs like radioactive decay, transients in electrical circuits, damped harmonic oscillator, forced harmonic oscillator, coupled oscillator, projectile motion.
2. Finding roots of transcendental and algebraic equations zeros of Legendre and Bessel functions of the first kind.
3. Solutions of systems of linear equations like mesh equations of electrical circuits etc.
4. Interpolation and fitting of data obtained in experiments.
5. Integration of functions, magnetic field due to a current carrying conductor, time period of pendulum, etc.
6. Solution to Wave equation, diffusion equation, Laplace's equation, Poisson's equation, time independent Schrödinger's equation (harmonic potential & s-wave H-atom).

Reference Books:

- Introduction to Numerical Analysis, S. S. Sastry, 5th edition, 2012, PHI Learning Pvt. Ltd.
- Computational Physics: An Introduction, R.C. Verma et al., 1999, New Age International Publishers, New Delhi.
- A first course in Numerical Methods, U. M. Ascher and C. Greif, 2012, PHI Learning
- Elementary Numerical Analysis, K. E. Atkinson, 3rd edition, 2007, Wiley India

MAJ020 (Theory+Tutorial): Advanced Mathematical Physics

Advanced Mathematical Physics	
45 Lectures (Theory)	**(Theory-3 credit; Tutorial-1 credit)**

Linear Vector Spaces

Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices.Inner products. Gram-Schmidt orthogonalization. Orthogonal and unitary transformations and their matrix representations.

Group Theory

Groups: Elementary properties of groups, uniqueness of solution, Subgroup, Centre of a group, Cosets of a subgroup, cyclic group, Permutation/Transformation. Homomorphism and Isomorphism of groups. Normal and conjugate subgroups. Application of group theory to study symmetry: 1. Group of symmetries of a square (D4 group) and 2. Group of symmetries of an equilateral triangle (S3 group). Group table of D4 and S3 group.

Introduction to nonlinear system

General idea of dynamical system, order of dynamical system, continuous and discrete, autonomous systems, solution of autonomous systems, (1D and 2D) critical points linear stability analysis and classification of critical points.

Reference Books

- Mathematical Methods for Physicists: Arfken and Weber, 2005, Academic Press
- Mathematical Methods for Physicists: A Concise Introduction: T. L. Chow, 2000, Cambridge Univ. Press.
- Elements of Group Theory for Physicists, A. W. Joshi, 1997, John Wiley.
- Group Theory and its Applications to Physical Problems, M. Hamermesh, 1989, Dover Publication
- Introduction to Mathematical Physics : Methods and Concepts, C.W.Wong, 2012, Oxford

University Press

- Introduction to Mathematical Probability, J. V. Uspensky, 1937, McGrawHill.
- Nonlinear Dynamics and Chaos, S. H. Strogatz, 2007, Levant Books.
- Understanding Nonlinear Dynamics, D.Kaplan and L. Glass, Springer.
- Elements of Group Theory for Physicists, A. W. Joshi, 1997, John Wiley.
- Linear Algebra, W. Cheney, E. W. Cheney, and D. R. Kincaid, 2012, Jones & Bartlett Learning

For FYUGP with Hons (FYUGHONS)

MAJ021 : Research Methodology

MAJ022 : Field work / Case Study / Tutorial / Term Paper / Industry Visit

MAJ023 : Group Discussion / Seminar Presentation / Grand Viva

For FYUGP with Hons and Research (FYUGHWRS)

IARD: Research Project / Dissertation

SEC003 (Theory)- Basic Instrumentation Skills

Basic Instrumentation Skills	
30 Lectures	**2 Credits**

Basics of Measurement

Instrument's accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. Multimeter: Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a Multimeter and their significance.

Electronic Voltmeter

Advantage over conventional Multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage measurement (block diagram only). Specifications of an electronic Voltmeter/ Multimeter and their significance.

Cathode Ray Oscilloscope

Block diagram of basic **CRO**. Construction of **CRT**, Electron gun, electrostatic focusing and acceleration (Explanation only–no mathematical treatment), brief discussion on screen phosphor, visual persistence and chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance.

Use of CRO for the measurement of voltage dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working.

Signal Generators and Analysis Instruments

Block diagram, explanation and specifications of low frequency signal generators. Pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis.

Impedance Bridges and Q-Meters

Block diagram of bridge: working principles of basic (balancing type) RLC bridge. Specifications of RLC bridge. Block diagram and working principles of a Q- Meter. Digital LCR bridges.

Reference Books

- A textbook in Electrical Technology, B. L. Theraja, S. Chand and Co.
- Performance and design of AC machines, M. G. Say, ELBS Edn
- Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill
- Logic circuit design, S. P. Vingron, 2012, Springer.
- Digital Electronics, S. Ghoshal, 2012, Cengage Learning.
- Electronic Devices and circuits, S. Salivahanan and N. S. Kumar, 3rd edition, 2012, Tata McGraw Hill
- Electronic circuits: Handbook of design and applications, U. Tietze and C. Schenk, 2008, Springer
- Electronic Devices, T. L. Floyd, 2008, Pearson India
- Electronic Instrumentation and Measurements by H.S. Kalsi, McGraw Hill India

SEC003 (Practical)-Basic Instrumentation Skills Lab

Laboratory Exercises	**1 Credit**

1. To observe the loading effect of a Multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a Multimeter for measuring high frequency voltage and currents.
3. To measure Q of a coil and its dependence on frequency.
4. Measurement of Voltage's frequency, time period and phase angle using **CRO**.
5. Measurement of R, L, and C using a**LCR** bridge/universal bridge.

Open Ended Experiments

1. Using a Dual Trace Oscilloscope
2. Converting the range of a given measuring instrument(Voltmeter, Ammeter)

MINA003 (Theory): Electricity and Magnetism

Electricity and Magnetism	
45 Lecture	**3 Credits**

Vector Analysis

Review of vector algebra (Scalar and Vector product), gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).

Electrostatics

Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic fields. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.

Magnetism

Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law.

Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para-and ferro- magnetic materials.

Electromagnetic Induction

Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in a magnetic field.

Reference Books

- Electricity and Magnetism, E. M. Purcell, 1986, McGraw-Hill Education
- Electricity and Magnetism,Vol.I, J. H. Fewkes and J.Yarwood,1991, Oxford Univ. Press
- Electricity and Magnetism, D. C. Tayal, 1988, Himalaya Publishing House.
- University Physics, R. L. Reese, 2003, Thomson Brooks/Cole.
- Introduction to Electrodynamics, 3rd edition, D. J. Griffiths, 1998, Benjamin Cummings.

MINA003 (Practical): Electricity and Magnetism Lab

ElectricityandMagnetism	
	1 Credits

List of Experiments

1. To use a Multimeter for measuring
    a. Resistances
    b. AC and DC Voltages
    c. DC Current
    d. Checking electrical fuses.
2. Ballistic Galvanometer:
    a. Measurement of charge and current sensitivity
    b. Measurement of CDR
    c. Determine a high resistance by Leakage Method
    d. To determine Self Inductance of a Coil by Rayleigh's Method.
3. To compare capacitances using De'Sauty's bridge.
4. Measurement of field strength B and its variation in a Solenoid (Determine dB/dx)
5. To study the Characteristics of a Series RC Circuit.
6. To study a series LCR circuit and determine its
    a. Resonant frequency
    b. Quality factor
7. To study a parallel LCR circuit and determine its:
    a. Anti-resonant frequency and
    b. Quality factor (Q)
8. To determine a Low Resistance by Carey-Foster's Bridge.
9. To verify the Thevenin and Norton theorems
10. To verify the Superposition, and Maximum Power Transfer Theorems

Reference Books
► Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
► Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publishers
► A Textbook Of Practical Physics, I. Prakash and Ramakrishna, 11th edition, 2011, Kitab Mahal
► Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning

MINA004 (Theory): Electricity and Magnetism

Electricity and Magnetism	
45 Lecture	**3 Credits**
Vector Analysis	
Review of vector algebra (Scalar and Vector product), gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).	
Electrostatics	
Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic fields. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.	

Magnetism

Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law.

Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para-and ferro-magnetic materials.

Electromagnetic Induction

Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in a magnetic field.

Reference Books

- Electricity and Magnetism, E. M. Purcell, 1986, McGraw-Hill Education
- Electricity and Magnetism, Vol.I, J. H. Fewkes and J.Yarwood, 1991, Oxford Univ. Press
- Electricity and Magnetism, D. C. Tayal, 1988, Himalaya Publishing House.
- University Physics, R. L. Reese, 2003, Thomson Brooks/Cole.
- Introduction to Electrodynamics, D. J. Griffiths, 3rd edition, 1998, Benjamin Cummings.

MINA004(Practical): Electricity and Magnetism Lab

Electricity and Magnetism Lab	
	1 Credits

List of Experiments

1. To use a Multimeter for measuring
    a. Resistances
    b. AC and DC Voltages
    c. DC Current
    d. Checking electrical fuses.
2. Ballistic Galvanometer:
    e. Measurement of charge and current sensitivity
    f. Measurement of CDR
    g. Determine a high resistance by Leakage Method
    h. To determine Self Inductance of a Coil by Rayleigh's Method.
3. To compare capacitances using De'Sauty's bridge.
4. Measurement of field strength B and its variation in a Solenoid (Determine dB/dx)
5. To study the Characteristics of a Series RC Circuit.
6. To study a series LCR circuitand determine its
    i. Resonant frequency
    j. Quality factor
7. To study a parallel LCR circuit and determine its:
    k. Anti-resonant frequency and
    l. Quality factor (Q)
8. To determine a Low Resistance by Carey-Foster's Bridge.
9. To verify the Thevenin and Norton theorems
10. To verify the Superpositionand Maximum Power Transfer Theorems

Reference Books

- Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, M. Nelson and J.M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publishers
- A Textbook of Practical Physics, I. Prakash and Ramakrishna, 11th edition, 2011, Kitab Mahal
- Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning

MINA005 (Theory): Thermal Physics

Thermal Physics	
45 Lectures	**3 Credits**

Laws of Thermodynamics

Thermodynamic Description of a system: Zeroth Law of thermodynamics and concepts of temperature. First law and internal energy, conversion of heat into work, Various Thermodynamic Processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law and Entropy, Carnot's cycle and theorem, Entropy changes in reversible and irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.

Thermodynamic Potentials

Enthalpy, Gibbs and Helmholtz Free energy, Internal Energy functions, Maxwell's relations and applications - Joule-Thomson Effect, Clausius-Clapeyron equation, Expression for

□□ − □□, $\frac{□□}{□□}$, and □□□ equations

Kinetic Theory of Gases

Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases.

Theory of Radiation

Blackbody Radiation, Spectral distribution, Concept of Energy density, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh-Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law.

Reference Books

- Thermal Physics, S. Garg, R. Bansal, and C. Ghosh, 1993, Tata McGraw Hill.
- A Treatise on Heat, M. N. Saha and B. N. Srivastava, 1969, Indian Press.
- Thermodynamics, E. Fermi, 1956, Courier Dover Publications.
- Heat and Thermodynamics, M. W. Zemansky and R. Dittman, 1981, McGraw Hill
- Thermodynamics, Kinetic theory and Statistical thermodynamics, F. W. Sears and
- G. L. Salinger, 1988, Narosa
- University Physics, R. L. Reese, 2003, Thomson Brooks/Cole.
- Thermal Physics, A. Kumar and S. P. Taneja, 2014, R. Chand Publications.

MINA005 (Practical): Thermal Physics Lab

Thermal Physics Lab	
	1 Credits

List of Experiments

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. Measurement of Planck's constant using blackbody radiation.
3. To determine Stefan's Constant.
4. To determine the coefficient of thermal conductivity of Cu by Searle's Apparatus.
5. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
6. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.
7. To determine the temperature coefficient of resistance by Platinum resistance thermometer.
8. To study the variation of thermo emf across two junctions of a thermocouple with temperature.
9. To record and analyze the cooling temperature of an hot object as a function of time using a thermocouple and suitable data acquisition system
10. To calibrate Resistance Temperature Device (RTD) using Null Method/Off-Balance Bridge

Reference Books

- Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, M. Nelson and J.M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publishers
- A Textbook of Practical Physics, I. Prakash and Ramakrishna, 11th edition, 2011, Kitab Mahal, New Delhi.
- A Laboratory Manual of Physics for Undergraduate Classes, D. P. Khandelwal, 1985, VaniPublication.

MINA006 (Theory): Thermal Physics

Thermal Physics	
45 Lectures	**3 Credits**

Laws of Thermodynamics

Thermodynamic Description of a system: Zeroth Law of thermodynamics and concepts of temperature. First law and internal energy, conversion of heat into work, Various Thermodynamic Processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law and Entropy, Carnot's cycle and theorem, Entropy changes in reversible and irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.

Thermodynamic Potentials

Enthalpy, Gibbs and Helmholtz Free energy, Internal Energy functions, Maxwell's relations and applications - Joule-Thomson Effect, Clausius-Clapeyron equation, Expression for

□□ − □□, $\frac{□□}{□□}$, and □□□ equations

Kinetic Theory of Gases

Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases.

Theory of Radiation

Blackbody Radiation, Spectral distribution, Concept of Energy density, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh-Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law.

Reference Books

- Thermal Physics, S. Garg, R. Bansal, and C. Ghosh, 1993, Tata McGraw Hill.
- A Treatise on Heat, M. N. Saha and B. N. Srivastava, 1969, Indian Press.
- Thermodynamics, E. Fermi, 1956, Courier Dover Publications.
- Heat and Thermodynamics, M. W. Zemansky and R. Dittman, 1981, McGraw Hill
- Thermodynamics, Kinetic theory and Statistical thermodynamics, F. W. Sears and
- G. L. Salinger, 1988, Narosa
- University Physics, R. L. Reese, 2003, Thomson Brooks/Cole.
- Thermal Physics, A. Kumar and S. P. Taneja, 2014, R. Chand Publications.

MINA006 (Practical): Thermal Physics Lab

Thermal Physics Lab	
	1 Credits

List of Experiments

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. Measurement of Planck's constant using blackbody radiation.
3. To determine Stefan's Constant.
4. To determine the coefficient of thermal conductivity of Cu by Searle's Apparatus.
5. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
6. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.
7. To determine the temperature coefficient of resistance by Platinum resistance thermometer.
8. To study the variation of thermo emf across two junctions of a thermocouple with temperature.
9. To record and analyze the cooling temperature of an hot object as a function of time using a thermocouple and suitable data acquisition system
10. To calibrate Resistance Temperature Device (RTD) using Null Method/Off-Balance Bridge

Reference Books

- Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publishers
- A Textbook of Practical Physics, I. Prakash and Ramakrishna, 11th edition, 2011, Kitab Mahal, New Delhi.
- A Laboratory Manual of Physics for Undergraduate Classes, D. P. Khandelwal, 1985, Vani Publication.

MINA007 (Theory): Waves and Optics

Waves and Optics	
45 Lecture	**3 Credits**
Superposition of Two Collinear Harmonic oscillations	
Linearity and Superposition Principle. Oscillations having equal frequencies and Oscillations having different frequencies (Beats).	
Superposition of Two Perpendicular Harmonic Oscillations	
Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequency and their uses.	
Wave Motion	
Transverse waves on a string. Traveling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity.	
Sound	
Simple harmonic motion-forced vibrations and resonance, Fourier's Theorem-Application to sawtooth wave and square wave–Intensity and loudness of sound-Decibels, Intensity levels, Acoustics of buildings: Reverberation and time of reverberation-Absorption coefficient, Sabine's formula-measurement of reverberation time-Acoustic aspects of halls and auditorium.	
Wave Optics	
Electromagnetic nature of light. Definition and Properties of wave front. Huygen's Principle.	
Interference	

Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index.

Diffraction

Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half- period zone analysis.

Polarization

Transverse nature of light waves. Plane polarized light–production and analysis. Circular and elliptical polarization.

Reference Books

- Fundamentals of Optics, F. A. Jenkins and H. E. White, 1976, McGrawHill
- Principles of Optics, B. K. Mathur, 1995, Gopal Printing
- Fundamentals of Optics, H. R. Gulati and D. R. Khanna, 1991, R. Chand Publications
- University Physics, F. W. Sears, M. W. Zemansky and H. D. Young, 1986. Addison-Wesley

MINA007 (Practical): Waves and Optics Lab

Waves and Optics	
	1 Credits

List of Practical

1. To investigate the motion of coupled oscillators
2. To determine the Frequency of an Electrically Maintained Tuning Fork byMelde's Experiment and to verify λ2 – T Law.
3. To study Lissajous Figures
4. Familiarization with Schuster's focussing; determination of angle of prism.
5. To determine the Refractive Index of the Material of a Prism using Sodium Light.
6. To determine Dispersive Power of the Material of a Prism using Mercury Light
7. To determine the value of Cauchy Constants.
8. To determine the Resolving Power of a Prism.
9. To determine wavelength of sodium light using Fresnel Biprism.
10. To determine wavelength of sodium light using Newton's Rings.
11. To determine the wavelength of Laser light using Diffraction of Single Slit.
12. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating
13. To determine the Resolving Power of a Plane Diffraction Grating.
14. To measure the intensity using photo sensor and laser in diffraction patterns of single and double slits.

Reference Books

- Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publishers
- A Textbook of Practical Physics, I. Prakash and Ramakrishna,11th edition, 2011, KitabMahal, NewDelhi.

MINA008 (Theory): Waves and Optics

Waves and Optics	
45 Lecture	**3 Credits**
Superposition of Two Collinear Harmonic oscillations	
Linearity and Superposition Principle. Oscillations having equal frequencies and Oscillations having different frequencies (Beats).	
Superposition of Two Perpendicular Harmonic Oscillations	
Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequency and their uses.	
Wave Motion	
Transverse waves on a string. Traveling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves.Spherical waves, Wave intensity.	
Sound	
Simple harmonic motion-forced vibrations and resonance, Fourier's Theorem-Application to sawtooth wave and square wave–Intensity and loudness of sound-Decibels, Intensity levels, Acoustics of buildings: Reverberation and time of reverberation-Absorption coefficient, Sabine's formula-measurement of reverberation time-Acoustic aspects of halls and auditorium.	
Wave Optics	
Electromagnetic nature of light. Definition and Properties of wave front. Huygen's Principle.	
Interference	
Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index.	

Diffraction

Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half- period zone analysis.

Polarization

Transverse nature of light waves. Plane polarized light–production and analysis. Circular and elliptical polarization.

Reference Books

- Fundamentals of Optics, F. A. Jenkins and H. E. White, 1976, McGrawHill
- Principles of Optics, B. K. Mathur, 1995, Gopal Printing
- Fundamentals of Optics, H. R. Gulati and D. R. Khanna, 1991, R. Chand Publications
- University Physics,F. W. Sears, M. W. Zemansky and H. D. Young, 1986, Addison-Wesley

MINA008 (Practical): Waves and Optics Lab

Waves and Optics	
	1 Credits

List of Practical

1. To investigate the motion of coupled oscillators
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify λ2 – T Law.
3. To study Lissajous Figures
4. Familiarization with Schuster's focussing; determination of angle of prism.
5. To determine the Refractive Index of the Material of a Prism using Sodium Light.
6. To determine Dispersive Power of the Material of a Prism using Mercury Light
7. To determine the value of Cauchy Constants.
8. To determine the Resolving Power of a Prism.
9. To determine wavelength of sodium light using Fresnel Biprism.
10. To determine wavelength of sodium light using Newton's Rings.
11. To determine the wavelength of Laser light using Diffraction of Single Slit.
12. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating
13. To determine the Resolving Power of a Plane Diffraction Grating.
14. To measure the intensity using photo sensor and laser in diffraction patterns of single and double slits.

Reference Books

- Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publishers
- A Textbook of Practical Physics, I. Prakash and Ramakrishna,11th edition, 2011, Kitab Mahal, NewDelhi.

MDC003/004 (Theory): Introduction to Cosmic Ray Physics

Multidisciplinary Course	
45 Lectures	**3 Credits**

Unit-I Cosmic Ray

Primary and secondary cosmic rays, historical discovery of cosmic ray, origin of primary and secondary cosmic rays, TIFR Balloon experiment to study cosmic rays, latitude effect of cosmic ray, Effect of altitude, magnetic field of the earth on cosmic rays, Acceleration of cosmic rays.

Unit-II Discovery of particles from the study of the cosmic ray

Historical discovery of π- meson and μ- meson qualitatively through cosmic ray studies on the earth.

Unit-III Energy and composition of cosmic ray particles

Ionization effect of cosmic rays on the earth's atmosphere, Energy range of cosmic rays, Pair production and Bremsstrahlung Processes, Air shower formation by High energy muon and High energy electron.

Unit-IV Cosmic ray detectors

Qualitative concept of Emulsion plate, scintillation counter, extensive air shower detectors.

Reference Books

- Nuclear Physics Vol II – S N Ghosal
- CENTENARY SYMPOSIUM 2012: DISCOVERY OF COSMIC RAYS. AIP Conference Proceedings, Volume 1516, pp. 9-16 (2013)
- Cosmic Ray Physics An Introduction to The Cosmic Laboratory -Veronica Bindi, Mercedes Paniccia, Martin Pohl