# B.Sc. (Hons.) in Physics

## under the Framework of Honours School System

## 2020-21

**PANJAB UNIVERSITY, CHANDIGARH**

**OUTLINES OF TESTS, SYLLABI AND COURSES OF READING FOR CHOICE BASED CREDIT SYSTEM B.Sc. (HONOURS) IN PHYSICS UNDER THE FRAMEWORK OF HONOURS SCHOOL SYSTEM (SEMESTER SYSTEM) EXAMINATION, 2020-21**

**OUTLINES OF TESTS**

**OBJECTIVE OF THE COURSE**

**To teach the fundamental concepts of Physics and their applications. The syllabus will provide comprehensive knowledge, and improve theoretical and practical skills of Physics subject and other Science subjects opted by the student. The syllabus contents are in accordance with UGC module for CHOICE BASED CREDIT SYSTEM pertaining to B.Sc. (Hons.) in Physics.**

## Semester I

### CORE COURSE (PHYSICS)

**Theory Papers:**

| | | |
|---|---|---|
| Core Course-1 (PHY-CT1): | Mathematical Physics – I | 100 Marks (4 credits) |
| Core Course-2 (PHY-CT2): | Mechanics | 100 Marks (4 credits) |

**Laboratory Practicals:**

**Practical Lab. Course-1 (PHY-PL1):** **100 Marks (4 credits)**

(i) Mathematical Physics – I
(ii) Mechanics
(iii) Electricity and Magnetism
(iv) Waves and Optics

### ABILITY ENHANCEMENT COMPULSORY COURSE

| | |
|---|---|
| Ability Enhancement Compulsory Course-I (AECC1) | 50 Marks (2 credits) |
| English/Environmental Science | 50 Marks (2 credits) |

### GENERIC ELECTIVE

**Each student may opt for any two of the generic electives offered by the other Departments of Panjab University out of following:**

(i) Mathematics
(ii) Chemistry
(iii) Computer Science
(iv) Statistics
(v) Geology
(vi) Economics
(vii) Any of the subjects offered by Biomedical Science/Life Science departments provided the student has studied Biology at 10+2 level.

| | |
|---|---|
| Generic Elective -1 (PHY-GE1) | 150 Marks (6 credits) |
| Generic Elective -2 (PHY-GE-2) | 150 Marks (6 credits) |

# Semester II

## CORE COURSE (PHYSICS)

**Theory Papers:**

| | | |
|---|---|---|
| **Core Course-3 (PHY-CT3):** | **Electricity and Magnetism** | **100 Marks (4 credits)** |
| **Core Course-4 (PHY-CT4):** | **Waves and Optics** | **100 Marks (4 credits)** |

**Laboratory Practicals:**

| | | |
|---|---|---|
| **Practical Lab. Course-2 (PHY-PL2)** | **Mathematical Physics – I<br>Mechanics<br>Electricity and Magnetism<br>Waves and Optics** | **100 Marks (4 credits)** |

## ABILITY ENHANCEMENT COMPULSORY COURSE

**Ability Enhancement Compulsory Course-II (AECC2)** **50 Marks (2 credits)**
**English/Environmental Science**

## GENERIC ELECTIVE

**Each student may opt for any two of the generic electives offered by the other Departments of Panjab University out of following:**

- **(i) Mathematics**
- **(ii) Chemistry**
- **(iii) Computer Science**
- **(iv) Statistics**
- **(v) Geology**
- **(vi) Economics**
- **(vii) Any of the subjects offered by Biomedical Science/Life Science departments provided the student has studied Biology at 10+2 level.**

| | |
|---|---|
| **Generic Elective -3 (PHY-GE3)** | **150 Marks (6 credits)** |
| **Generic Elective -4 (PHY-GE4)** | **150 Marks (6 credits)** |

# Semester III

## CORE COURSE (PHYSICS)

**Theory Papers:**

| | | |
|---|---|---|
| Core Course-5 (C5): | Mathematical Physics - II | 100 Marks (4 credits) |
| Core Course-6 (C6): | Thermal Physics | 100 Marks (4 credits) |
| Core Course-7 (C7): | Digital Systems and Applications | 100 Marks (4 credits) |

**Practicals:**

| | | |
|---|---|---|
| Core Course-5 (C5): | Mathematical Physics - II | 50 Marks (2 credits) |
| Core Course-6 (C6): | Thermal Physics | 50 Marks (2 credits) |
| Core Course-7 (C7): | Digital Systems and Applications | 50 Marks (2 credits) |

## SKILL ENHANCEMENT COMPULSORY COURSE

**Each student shall opt for any one of the skill enhancement courses offered out of following:**

| | |
|---|---|
| 1. PHY-SEC1: Physics Enhancement Skills | 50 Marks (2 credits) |
| 2. PHY-SEC2: Computational Physics Skills | 50 Marks (2 credits) |
| 3. PHY-SEC3: Electrical Circuits and Network Skills | 50 Marks (2 credits) |
| 4. PHY-SEC4: Basic Instrumentation Skills | 50 Marks (2 credits) |
| 5. PHY-SEC5: Renewable energy and energy harvesting | 50 Marks (2 credits) |

## GENERIC ELECTIVE

**Each student may opt for any one of the generic electives studied in semesters I and II offered by the other Departments of Panjab University out of following:**

(i) Mathematics
(ii) Chemistry/BioChemistry
(iii) Economics
(iv) Computer Science
(v) Statistics
(vi) Geology
(vii) Any of the subjects of Biomedical Sciences/Life Sciences provided the student has studied Biology at 10+2 level.

**Generic Elective -5 (GE5)** — 150 Marks (6 credits)

# Semester IV

## CORE COURSE (PHYSICS)

**Theory Papers:**

| | | |
|---|---|---|
| Core Course-5 (C8): | Mathematical Physics - III | 100 Marks (4 credits) |
| Core Course-6 (C9): | Elements of Modern Physics | 100 Marks (4 credits) |
| Core Course-7 (C10): | Analog Systems and Applications | 100 Marks (4 credits) |

**Practicals:**

| | | |
|---|---|---|
| Core Course-8 (C8): | Mathematical Physics - III | 50 Marks (2 credits) |
| Core Course-9 (C9): | Elements of Modern Physics | 50 Marks (2 credits) |
| Core Course-10 (C10): | Analog Systems and Applications | 50 Marks (2 credits) |

## SKILL ENHANCEMENT COMPULSORY COURSE

**Each student shall opt for any one of the skill enhancement courses (other than that taken during Semester III) offered out of following:**

| | |
|---|---|
| 1.PHY-SEC1: Physics Enhancement Skills | 50 Marks (2 credits) |
| 2.PHY-SEC2: Computational Physics Skills | 50 Marks (2 credits) |
| 3.PHY-SEC3: Electrical Circuits and Network Skills | 50 Marks (2 credits) |
| 4.PHY-SEC4: Basic Instrumentation Skills | 50 Marks (2 credits) |
| 5.PHY-SEC5: Renewable Energy and Energy Harvesting | 50 Marks (2 credits) |

## GENERIC ELECTIVE

**Each student may opt for any one of the generic electives studied in semesters I and II offered by the other Departments of Panjab University out of following:**

(i) Mathematics
(ii) Chemistry/Biochemistry
(iii) Economics
(iv) Computer Science
(v) Statistics
(vi) Geology
(vii) Any of the subjects of Biomedical Sciences/Life Sciences provided the student has studied Biology at 10+2 level.

**Generic Elective - 6 (GE6)** — **150 Marks (6 credits)**

## EVALUATION

(i) There shall be one Mid Term Examination of 20% Marks (20 marks) for theory papers in each semester. End-semester examination will be of 80% of total marks (80 marks).

(ii) Evaluation of Practicals for Core and DSE Subjects - The practical examination of all the core/DSE courses in a particular semester will be held together.
There shall be internal assessment component for practicals of all the core/DSE courses having weightage of 20% of the allocated marks. It will be based on performance of the students in the laboratory, viva voice of each experiment, regularity (attendance) in the class and number of experiments performed.
The final end-semester examination of all the core/DSE courses will be of 80% of the total marks and 4 (3+1) hours duration. The evaluation will be based on the following components for each of the the Core and DSE courses:

There will be written comprehensive test of 60 minutes duration containing short answer questions and covering all the experiments. It will be consisting of various sections corresponding to the core/DSE courses. The test will have a weightage of 20 % of the total allocated marks and will be jointly set by the teachers involved in the examination.

Viva voce by the external examiner (weightage - 20%) related to the practicals core/DSE courses.

Performance in the experiments done during the Practical examination (weightage - 40 %)

(iii) Evaluation of Practicals for Generic Elective Subjects - There shall be internal assessment for practicals having weightage of 20% marks of the total marks. It will be based on performance of the students in the laboratory, viva voice of each experiment, regularity (attendance) in the class and number of experiments performed. The final end-semester examination will be of 80% marks and 3 hours duration. The evaluation will be based on the following components with equal weightage:

(i) performance in the allotted Experiment and (ii) evaluation by the External examiner in the end-semester examination

(i) Evaluation in Skill Development Courses : Projects/Jobs will be allocated to the students and will be evaluated by a Committee during (i) the midterm interaction with weightage 30 %, (ii) end-semester evaltion based on the presentation and project report, and innovation will be given extra credits.

(ii) To qualify a Course consisting of Theory and Practical parts, the student has to obtain minimum of 40% marks in each of the examinations held for the Theory and Practical parts. Failing in one component (Theory/Practical), the candidate has to reappear in that component only.

### Pattern of end-semester question paper

(i) Nine questions in all with equal weightage. It will include one Compulsory question (consisting of short answer type questions) covering whole syllabus. There will be no choice in this question.

(ii) The remaining eight questions will be placed in Four Units comprising two questions each, uniformly covering the whole syllabus. Students will attempt one question from each unit and the compulsory question. The candidate will be asked to attempt five questions.

# Syllabus (Teaching and Examination)

**The details related to admissions, teaching, and conduct & evaluation of the examinations of students are given in a separate document "Regulations of the B.Sc (Hons.) under the framework of Honours School System". The teaching hours and credits allocation, and the question paper pattern for the Mid Term and End-semester examinations and their evaluations for various courses of B.Sc (Hons.) are given in syllabus of each Course, which is supplemented by the procedures given below:**

1. **TEACHING : The number of Lectures mentioned for each Course is 60 (45 + 15) hours, which includes 45 contact hours of teaching to be delivered exclusively by the Teacher as per the scheduled time table and 15 contact hours are for interaction, discussion, tutorials, assignments and seminars (attended/ delivered) by the student.**

2. **EXAMINATION : There shall be Mid-term Examination (75 min duration) of 20% Marks for theory papers in each semester. End-semester examinations (3 hours duration) shall be of 80% of total marks. The question paper for the Mid-term examinations should be such that more emphasis is given to the problems related to the subject. Only in special cases, where the student misses the mid-term examination, retest for the mid-term examinations will be held. For a student who has used first mid term examination chance, teacher may allow him/her to take another midterm test but the maximum score 80% of the first chance of the mid-term test.**

   **The End-semester question paper will consist of seven questions in all with equal weightage. It will include one Compulsory question (consisting of short answer type questions) covering whole syllabus. There will be no choice in this question. The candidate will be asked to attempt five questions including the compulsory question.**

## 3. EVALUATION :

### A. Evaluation of Practicals Subjects - The practical examination of all the Core/DSE courses in a particular semester will be held together.

**There shall be internal assessment component for practicals of all the Core/DSE courses having weightage of 20% of the allocated marks. It will be based on practical performance of the students in the laboratory, number of experiments performed, written report/record of the experiments and regularity (attendance) in the class.**

**The final end-semester examination of all the core/DSE courses will be of 80% of the total marks and 4 (3+1) hours duration. The evaluation will be based on the following components:**

**(i) There will be written comprehensive test of 1 hour duration containing short answer questions and covering all the experiments. It will be consisting of various sections corresponding to the core/DSE courses. The test will have a weightage of 20% of the total allocated marks and will be jointly set by the teachers involved in the examination.**

(ii) Performance in the allotted experiments done during the End-semester Practical examination (weightage - 25 %)

(iii) Viva voce by the external examiner (weightage - 20%) related to the practicals.

(iv) Continuous evaluation by the internal examiners based on the Viva Voce of the checked practicals (weightage - 15%).

B. Evaluation of Practicals for Generic Elective Subjects - There shall be internal assessment for practicals having weightage of 20% marks of the total marks. It will be based on practical performance of the students in the laboratory, regularity (attendance) in the class and number of experiments performed. The final end-semester examination will be of 80% marks and 3 hours duration. The evaluation will be based on the following components:

(i) Performance in the allotted Experiment (30%)

(ii) Evaluation by the External examiner in the end-semester examination (25%) and

(iii) Continuous evaluation by the internal examiners based on the Viva Voce of the checked practicals (25%).

C. Evaluation in Skill Development Courses : Projects/Jobs will be allocated to the students and will be evaluated by a Committee during (i) the midterm interaction with weightage 30 %, (ii) end-semester evaltion based on the presentation and project report, and innovation will be given extra credits.

4. PASSING CRITERIAN : To qualify a Course, the student has to obtain minimum of 40% marks. The failing candidate has to reappear in end-semester examination. The grading system is detailed in a separate document "Regulations of the B.Sc (Hons.) under the framework of Honours School System".

## PREAMBLE

Physics is the science that involves the study of matter and its motion through space and time, along with related concepts. One of the most fundamental scientific disciplines, the main goal of physics is to understand how the universe evolved and behaves. New ideas in physics often explain the fundamental mechanisms of other sciences and the boundaries of physics are not rigidly defined. Physics also makes significant contributions through advances in new technologies that arise from theoretical breakthroughs.

After partition of India, the Department of Physics was re-established in 1947, in Govt. College, Hoshiarpur (Punjab) and later, shifted to the present campus in August 1958. With the modest beginning of research in high-energy particle physics (nuclear emulsion) and optical UV spectroscopy, the research activities got a major filip with installation of cyclotron accelerator in late sixties. The department strengthened its research activities through UGC Special Assistance Programme (SAP) from 1980 to 1988 and College Science Improvement Programme from 1984 to 1991. In 1988, the department was accorded the status of Center of Advanced Study (CAS) by UGC with three major thrust areas, Particle physics, Nuclear physics and Solid-state physics, which is a unique feature in itself. The department is now in CAS fifth phase. The department participates in various national and international research initiatives in Accelerator-based reaserch in High Energy Physics, Nuclear Physics and Solid-State Physics. The department houses Cyclotron lab, EDXRF lab., Detector development lab., Experimental Solid-state Physics laboratories, Molecular Physics lab. and Advanced computation facilities for analyses of data from High Energy Physics, and Nuclear Spectroscopy and Reaction experiments. High Performance Computation facility is available for Condensed matter Physics and Nuclear Physics simulation calculations.

The Physics department is running undergraduate and postgraduate courses in Physics, and Physics (Specialization in Electronics) under the Honours School System. At present the department has strength of about 30 faculty members and Post-doctoral fellows, 50 non-teaching/administrative staff, 130 research students and 450 graduate and undergraduate students. The department has well equipped Practical and computing laboratories, Workshops and Library. The department has an 11-inch telescope to encourage/inculcate the scientific temper among public and with particular emphasis on college and school students. The department houses Indian Association of Physics Teachers (IAPT) office and actively leads in IAPT and Indian Physics Association (IPA) activities.

## COURSE STRUCTURE

| SEMESTER I (Credits = 26, Marks = 650) | | SEMESTER II (Credits = 26, Marks = 650) | |
|---|---|---|---|
| CT1 | PHY-CT1: Mathematical Physics – I | CT3 | PHY-CT3: Electricity and Magnetism |
| CT2 | PHY-CT2: Mechanics | CT4 | PHY-CT4: Waves and Optics |
| PL1 | PHY-CP1 : Physics Laboratory-I | PL2 | PHY-CP2 : Physics Laboratory-II |
| AECC1 | PHY-AECC1: English/ Environmental Science | AECC2 | PHY- AECC2: English/ Environmental Science |
| GE1* | | GE3* | |
| GE2* | | GE4* | |
| **SEMESTER III (Credits = 26, Marks = 650)** | | **SEMESTER IV (Credits = 26, Marks = 650)** | |
| CT5 | PHY-CT5: Mathematical Physics - II | CT8 | PHY-CT8: Mathematical Physics - III |
| CT6 | PHY-CT6: Thermal Physics | CT9 | PHY-CT9: Elements of Modern Physics |
| CT7 | PHY-CT7: Digital Systems and Applications | CT10 | PHY-CT10: Analog systems and Applications |
| PL3 | PHY-CP3 : Physics Laboratory-III | PL4 | PHY-CP4 : Physics Laboratory-IV |
| SEC1** | | SEC2** | |
| GE5* | | GE6* | |
| **SEMESTER V (Credits = 24, Marks = 600)** | | **SEMESTER VI (Credits = 24, Marks = 600)** | |
| CT11 | PHY-CT11: Quantum Mechanics and Applications | CT13 | PHY-CT13:Electromagnetic Theory |
| CT12 | PHY-CT12: Solid State Physics | CT14 | PHY-CT14: Statistical Mechanics |
| PL5 | PHY-CP5 : Physics Laboratory-V | PL6 | PHY-CP6 : Physics Laboratory-VI |
| DSE1# | | DSE3# | |
| DSE2# | | DSE4# | |

**CT: Core Courses Theory; PL: Practical Laboratory Courses; GE: General Elective; AECC: Ability Enhancement Compulsory Courses; SEC: Skill Enhancement Courses; DSE: Discipline Specific Elective Theory Courses**

*GE - General Elective courses are to be selected by the student from the pool of GE subjects - Mathematics, Chemistry/Biochemistry/Biophysics, Geology, Statistics, Economics and Computer Science offered by other Departments of the University.

**SEC - SKILL Enhancement Courses are to be selected by the student from the courses offered by the Physics Department in Semesters III and IV.

#DSE - DISCIPLINE SPECIFIC ELECTIVE COURSES are to be selected by the student from the courses offered by the Physics Department in semesters V and VI.

***SKILL ENHANCEMENT COURSES (any one per semester in semesters III and IV)**

1. PHY-SEC1: Physics Enhancement Skills
2. PHY-SEC2: Computational Physics Skills
3. PHY-SEC3: Electrical Circuits and Network Skills
4. PHY-SEC4: Basic Instrumentation Skills
5. PHY-SEC5: Renewable Energy and Energy Harvesting

**#DISCIPLINE SPECIFIC ELECTIVE COURSES**

(Any two per semester in semesters V and VI. Course under these will be offered only if a minimum of 10 students opt for the same.)

1. PHY-DSE1: Nuclear Physics
2. PHY-DSE2: Experimental Techniques
3. PHY-DSE3: Atomic and Molecular Physics
4. PHY-DSE4: Particle Physics
5. PHY-DSE5: Physics of Resonance Techniques
6. PHY-DSE6: Dissertation

**GENERIC ELECTIVE SUBJECTS (Offered by by Physics Department) for the students of Bio-Medical Sciences (BMS) and Physical Sciences (PHS):**

| Bio-Medical Sciences and Physical Sciences | | |
|---|---|---|
| Semesters I | PHY-C-GE1 | Electricity and Magnetism |
| Semesters II | PHY-C-GE2 | Elements of Modern Physics |
| Semesters III | PHY-C-GE3 | Waves and Optics |
| Semesters IV | PHY-C-GE4 | Digital, Analog Circuits and Instrumentation |

## Credits and Maximum Marks:

1. Core Theory Courses (CT1-CT14)

   Credits = 04 each Total

   marks = 100 each

2. Practical Laboratory Courses (PL1-

   PL2) Credits = 04 each

   Total marks = 100 each

   Practical Courses (PL3-PL4)

   Credits = 06 each

   Total marks = 150 each

   Practical Courses (PL5-PL6)

   Credits = 08 each

   Total marks = 200 (150+50) each

3. Discipline Specific Elective (DSE1-

   DSE4) Credits = 06 each

   Total marks = 150 each

4. Skill Enhancement Courses (SEC1-SEC2)

5. Ability Enhancement (AECC1-AECC2)

   Credits = 02 each

   Total marks = 50 each

6. Generic Elective (GE1-GE6)

   Credits = 06 each Total

   marks = 150 each.

**NOTE :** The number of Lectures mentioned for each Course is 60 (45 + 15), which includes 45 contact hours of teaching to be delivered exclusively by the Teacher as per the scheduled time table and 15 contact hours are for interaction, discussion, tutorials, assignments and seminars (attended/ delivered) by the student.

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## Semester I

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## PHY-CT1: MATHEMATICAL PHYSICS-I

### THEORY

**Total Lectures (45+15)** **Credits: 04**

**Max. Marks : 100**

**Objective: The emphasis of course is on applications in solving problems of interest to physicists. The objective of the course is to equip the student with the mathematical techniques that are required for understanding theoretical treatment in different Physics subjects being taught.**

**Calculus:**

**Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only). (2 Lectures)**

**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. Particular Integral. (13 Lectures)**

**Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers. (6 Lectures)**

**Vector Calculus: Recapitulation of vectors: 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. (5 Lectures)**

**Vector Differentiation: 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. (8 Lectures)**

**Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of**

infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs). (14 Lectures)

Orthogonal Curvilinear Coordinates: Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. (6 Lectures)

**Introduction to probability:**

Independent random variables: Probability distribution functions; binomial, Gaussian, and Poisson, with examples. Mean and variance.

Dependent events: Conditional Probability. Bayes' Theorem and the idea of hypothesis testing. (4 Lectures)

**Dirac Delta function and its properties:**

Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function. (2 Lectures)

**Suggested Reading**


- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., 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, 5 Ed., 2012, 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

## PHY-CT2: MECHANICS

## THEORY

**Total Lectures: 60** **Credits: 04**

**Max. Marks: 100**

**Objective: The purpose of the course is to train the students in the Newtonian Mechanics and Special Theory of Relativity formalisms to an extent that they can use these in the modern branches of Physics.**

**Fundamentals of Dynamics: Reference frames. Inertial frames; Review of Newton's Laws of Motion. Galilean transformations; Galilean invariance. Momentum of variable-mass system: motion of rocket. Motion of a projectile in Uniform gravitational field. Conservation of Energy, Conservative forces, Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse. Angular Momentum about the Centre of mass, Rotational invariance, Shape of Galaxy.** **(6 Lectures)**

**Work and Energy: Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy.** **(4 Lectures)**

**Elastic and Inelastic Scattering : Types of scattering and conservation laws, Laboratory and centre of mass systems, collision of particles which stick together, General elastic collision of particles of different mass, Cross-section of elastic scattering, Rutherford scattering.**

**(3 Lectures)**

**Rotational Dynamics: Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation. Cylinder on an accelerated rough plane, Behaviour of angular momentum vector, Principal axes and Euler's equations, Elementary Gyroscope, Symmetrical Top. (12 Lectures) Elasticity: Relation between Elastic constants. Twisting torque on a Cylinder or Wire.**

**(3 Lectures)**

**Fluid Motion: Kinematics of Moving Fluids: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube.** **(2 Lectures)**

Gravitation and Central Force Motion: Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. Force between a Point Mass and Spherical shell. Force between a Point Mass and Solid Sphere, Gravitational and Electrostatic self-energy. Gravitational energy of the Galaxy and of uniform sphere. (3 Lectures)

Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). (6 Lectures)

Oscillations: SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor. (5 Lectures)

Non-Inertial Systems: 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. (4 Lectures)

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, Transformation of Force, Four vectors. Problems of Relativistic Dynamics: Acceleration of charged particle by constant electric field, transverse Electric field. (12 Lectures)

## Suggested Reading

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.

**Additional Suggested Reading**

1. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
2. University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
3. Physics for scientists and Engineers with Modern Phys., J.W. Jewett, R.A. Serway, 2010, Cengage Learning
4. Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

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## PHY-PL1 : PHYSICS LABORATORY-I

**Total Lectures : 60** **Credits: 04**

**Max. Marks : 100**

**Objective : This course aims to impart practical knowledge to students related to the Core Papers, Mechanics, Electricity and Magnetism, and Waves and Optics, and Mathematical Physics–I.**

**Note: The Course content consists of Practicals of the Core Papers, Mechanics, Electricity and Magnetism, and Waves and Optics, and Mathematical Physics–I. The experiments will be performed by the students during the Semesters I and II. Basic experiments of these papers will be covered in Semester I and the rest will be done in Semester II. Atleast 12 experiments, taking atleast Two from each of the Sections I-IV are to be performed in each Semester without repetition. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.**

### SECTION – I
### MECHANICS (PRACTICALS)

**Objective: The laboratory exercises in this section have been so designed that the students learn to verify some of the concepts learnt in the theory courses. They are trained in carrying out precise measurements and handling sensitive equipments.**

1. Use of Vernier callipers, Screw gauge, Spherometer, Barometer, Sphygmomanometer, Lightmeter, dry and wet thermometers, TDS/conductivity meter and other measuringinstruments based on applications of the experiments. Use of Plumb line and Spirit level.
2. To study the random error in observations.
3. Determination of height (of inaccessible structure) using sextant.
4. To study the Motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
5. To determine the Moment of Inertia of a Flywheel.
6. To determine g and velocity for a freely falling body using Digital Timing Technique
7. To determine the value of g using Kater's Pendulum.
8. To study the variation of time period with distance between centre of suspension and centre of gravity for a bar pendulum and to determine: (i) Radius of gyration of the bar about an axis through its C.G. and perpendicular to its length. (ii) The value of g in the laboratory.
9. Determination of coefficient of viscosity of a given liquid by Stoke's method. Study its temperature dependence.
10. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
11. To determine the Young's Modulus of a Wire by Optical Lever Method.
12. To determine the Young's modulus by (i) bending of beam using traveling microscope/laser, (ii) Flexural vibrations of a bar.
13. Determination of modulus of rigidity by (i) dynamic method Maxwell's needle/Torsional pendulum; (ii) Forced torsional oscillations excited using electromagnet.
14. To determine the elastic Constants of a wire by Searle's method.
15. To study one dimensional collision using two hanging spheres of different materials.

## SECTION – II

## ELECTRICITY AND MAGNETISM (PRACTICALS)

**Objective: The aim of this section of the course is to build an understanding about various components of an electrical circuit and to develop skill to measure the related physical quantities.**

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To determine an unknown Low Resistance using Potentiometer.

3. To determine an unknown Low Resistance using Carey Foster's Bridge.
4. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
5. To determine the value of an air capacitance by de-Sauty Method and to find permittivity of air. Also to determine the dielectric constant of a liquid.
6. To verify the Thevenin and Norton theorems.
7. To verify the Superposition, and Maximum power transfer theorems.
8. To determine self inductance of a coil by Anderson's bridge.
9. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
10. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
11. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer
12. Determine a high resistance by leakage method using Ballistic Galvanometer.
13. To determine self-inductance of a coil by Rayleigh's method.
14. To determine the mutual inductance of two coils by Absolute method.
15. Determination of E.C.E. of hydrogen and evaluation of Faraday and Avogadro constants.
16. To study the magnetic field produced by a current carrying solenoid using a pick-up coil/Hall sensor and to find the value of permeability of air.
17. To determine the frequency of A.C. mains using sonometer.
18. To determine the resistance of an electrolyte for A.C current and study its concentration dependence. Also to study temperature dependence.
19. Study of temperature dependence resistivity of Cu conductor, Manganin/constantin alloy and semiconductor (FET channel).
20. To measure thermo e.m.f. of a thermocouple as a function of temperature and find inversion temperature.
21. To study C.R.O. as display and measuring device by recording sines and square waves, output from a rectifier, verification (qualitative) of law of electromagnetic induction and frequency of A.C. mains.
22. To plot the Lissajous figures and determine the phase angle by C.R.O.
23. To study B-H curves for different ferromagnetic materials using C.R.O.
24. Determination of low inductance by Maxwell-Wein bridge.
25. Study of R.C. circuit with a low frequency a.c. source.

26. Studies based on LCR Board: Impedance of LCR circuit and the phase and between voltage and current.

## SECTION – III

## WAVES AND OPTICS (PRACTICALS)

**Objective:** The course content in this section covers experiments related to damped, driven and forced oscillations, wave motion in media. Properties and Characteristics of light through experiments related to interference and diffraction phenomenon are high lighted.

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify $\lambda^2$ –T law.
2. To investigate the motion of coupled oscillators.
3. To study Lissajous Figures.
4. Familiarization with: Schuster`s focusing; determination of angle of prism.
5. To determine refractive index of the Material/liquid of a prism using sodium source.
6. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
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 (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
12. To determine dispersive power and resolving power of a plane diffraction grating.
13. To study Malus's law of polarization.
14. To find the resolving power and magnification of a telescope.
15. To find the resolving power and magnification of a diffraction grating.
16. To study hydrogen/Neon gas discharge tube spectrum using diffraction grating.
17. To study temperature dependence of refractive index of organic liquid using Abbe's refractometer.
18. To study the variation of specific rotation of sugar solution with concentration.
19. To measure power distribution and divergence parameters of He-Ne and Semiconductor

lasers.

20. To study Moire's fringe patterns and applications to measure small distance and angle.

## SECTION – IV

## MATHEMATICAL PHYSICS-I (PRACTICALS)

Objective: The aim of this section of Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.

Highlights the use of computational methods to solve physical problems

The course will consist of lectures (both theory and practical) in the Lab

Evaluation done not on the programming but on the basis of formulating the problem

Aim at teaching students to construct the computational problem to be solved

Students can use any one operating system Linux or Microsoft Windows

| Topics | Description with Applications |
|---|---|
| Introduction and Overview | Computer architecture and organization, memory and Input/output devices |
| Basics of scientific computing | Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow- emphasize the importance of making equations in terms of dimensionless variables, Iterative methods |
| Errors and error Analysis | Truncation and round off errors, Absolute and relative errors, Floating point computations. |
| Review of C & C++ Programming fundamentals | Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulatorsfordataformatting,Control statements(decisionmakingandlooping statements) (If statement. If else Statement. Nested if Structure. Else-if Statement. Ternary Operator. Goto Statement. Switch Statement. |

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|---|---|
| | Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops), Arrays (1D & 2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects. |
| Programs: | Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search |
| Random number generation | Area of circle, area of square, volume of sphere, value of pi (π) |
| Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods | Solution of linear and quadratic equation, solving α tanα ; $I = I_o\left[\frac{\sin \alpha}{\alpha}\right]^2$ in optics |
| Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation | Evaluation of trigonometric functions e.g. sin θ, cos θ, tan θ etc. |
| Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method | Given Position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of B-H Hysteresis loop |
| Solution of Ordinary Differential Equations (ODE)<br>First order Differential equation Euler, modified Euler and Runge-Kutta (RK) second and fourth order methods | First order differential equation<br>Radioactive decay<br>Current in RC, LC circuits with DC source<br>Newton's law of cooling<br>Classical equations of motion<br>Attempt following problems using RK 4 order method:<br>Solve the coupled differential equations |

| | |
|---|---|
| | $\frac{dx}{dt} = y + x - \frac{x^3}{3}; \ \frac{dy}{dt} = -x$<br>**for four initial conditions**<br>**x(0) = 0, y(0) = -1, -2, -3, -4.**<br>**Plot x vs y for each of the four initial conditions**<br>**on the same screen for $0 \le t \le 15$**<br>**The differential equation describing the motion of a pendulum is [illegible]. The pendulum is released from rest at an angular displacement α and θ'(0) = 0. Solve the equation for α = 0.1, 0.5 and 1.0 and plot θ as a function of time in the range $0 \le t \le 8\pi$. Also plot the analytic solution valid for small θ (sin θ = θ)** |

**Suggested Reading (Sections - I, II, III)**


1. **Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House**
2. **Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers**
3. **A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal**
4. **Engineering Practical Physics, S. Panigrahi & B.Mallick, 2015, Cengage Learning India Pvt. Ltd.**
5. **Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.**
6. **A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.**

1. **Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.**
2. **Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw - Hill Pub.**
3. **Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rd Edn. , 2007, Cambridge University Press.**
4. **A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.**
5. **Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn . , 2007 , Wiley India Edition.**
6. **Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.**
7. **An Introduction to Computational Physics, T.Pang, 2nd Edn. , 2006,Cambridge Univ. Press**
8. **Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.**


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**Semester II**

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## PHY-C3T: ELECTRICITY AND MAGNETISM

### THEORY

**Total Lectures : 60** **Credits: 4**

**Max. Marks: 100**

**Objective : The student is exposed to Electrostatics and Magnetostatics including Boundary value problems, Maxwell equations and their applications and analysis of Alternating current circuits.**

**Electric Charges and Fields : Conservation and quantization of charge, Coulomb's Law, Energy of a system of charges. Electric field lines, Electric flux, Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. (6 Lectures)**

**Conservative nature of Electrostatic Field. Electrostatic Potential. Potential as line integral of field, potential difference, Gradient of a scalar function, Derivation of the field from the potential, potential of a charge distribution, Uniformly charged disc. Force on a surface charge, energy associated with an electric field, Gauss's theorem and differential form of Gauss's law, Laplacian and Laplace's equation, Poisson's equation. Force and Torque on a dipole.**

**(6 Lectures)**

**Electric Fields Around Conductors : Conductors and insulators, General electrostatic problem. Boundary conditions, Uniqueness theorem, Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Method of Images and its application to: Plane Infinite Sheet and Sphere. (10 Lectures)**

**Dielectric Properties of Matter: Dielectrics, Moments of a charge distribution, Potential and field of a dipole, Atomic and molecular dipoles, Induced dipole moments, Permanent dipole moments, electric field caused by polarized matter, field of a polarized sphere, dielectric sphere in a uniform field, Gauss's law in a dielectric medium, Electrical susceptibility and atomic polarizability, Energy changes in polarization, Polarization in changing fields. Displacement vector D. Relations between E, P and D.** **(8 Lectures)**

**The Fields of Moving Charges : Magnetic forces, Measurement of a charge in motion, invariance of charge, Electric field measured in different frames of reference, Field of a point charge moving with constant velocity, Field of a charge that starts or stops, Force on a moving charge, Interaction between a moving charge and other moving charges.** **(4 Lectures)**

**Magnetic Field: Magnetic force between current elements and definition of Magnetic Field B. Biot-Savart's Law and its simple 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 to (1) Solenoid and (2) Toroid. Properties of B: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field. Change in B at a current sheet; Transformations of electric and magnetic fields. Rowland's experiment, Hall effect.**

**(9 Lectures)**

**Magnetic Properties of Matter: Response of various substances to magnetic field, Force on a dipole in an external field, Electric currents in Atoms, Electron spin and Magnetic moment, types of magnetic materials, Magnetization vector (M). Magnetic Intensity (H). Magnetic Susceptibility and permeability. Relation between B, H, M. Ferromagnetism. B-H curve and hysteresis.**

**(4 Lectures)**

**Electromagnetic Induction : Universal law of induction, Mutual inductance, Reciprocity theorem, Self inductance, Energy stored in a Magnetic field. A circuit containing self inductance, Displacement current and Maxwell's equations.** **(6 Lectures)**

**Alternating Current Circuits: A resonance circuit, Kirchhoff's laws for A.C. networks. Phasor, Complex Reactance and Impedance. Skin effect, Power and Energy in A.C. circuits, Anderson's Bridge, Instantaneous Power, Average Power, Reactive Power, Power Factor.**

**Sinusoidal Circuit Analysis for RL, RC and RLC Circuits. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit.**

**(4 Lectures)**

**Ballistic Galvanometer: Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CDR. (3 Lectures)**

**Suggested Reading**


1. **Electricity and Magnetism (Berkley, Phys. Course 2), Edward M. Purcell, 1986 McGraw-Hill Education**
2. **Electricity and Magnetism: A.S. Mahajan & A.A. Rangwala (Tata- McGraw Hill), 1988.**
3. **Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw**
4. **Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.**
5. **Feynman Lectures Vol.2, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education**
6. **Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.**
7. **Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press.**


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## PHY-C4T : WAVES AND OPTICS

### THEORY

**Total Lectures : 60** **Credits: 4**

**Max. Marks : 100**

**Objective : The course covers Harmonic oscillations and coupled oscillations, wave motion in damped, driven media. It also covers the Interference, diffraction and polarisation of light and their applications with emphasis on Holography.**

**Superposition of Collinear Harmonic oscillations: Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences.**

**Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses. (4 Lectures)**

**Coupled oscillations : Stiffness coupled oscillations, normal coordinates and modes of vibrations. Normal frequencies, Forced vibrations and resonance of coupled oscillators, masses on string-coupled oscillators. (3 Lectures)**

**Wave Motion: Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves. (6 Lectures)**

**Velocity of Waves: Velocity of Transverse Vibrations of Stretched Strings. longitudinal waves on a rod, Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction. Reflection and transmission of transverse waves on a string at the discontinuity. Impedance matching, eigen frequencies and eigen functions for stationary waves ona string. (6 Lectures)**

**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. (7 Lectures)**

**Wave Optics: Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence. (3 Lectures) 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. (9 Lectures) Interferometer: Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer. (4 Lectures)**

**Diffraction: Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula. (Qualitative discussion only) (2 Lectures)**

**Fraunhofer diffraction: Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating. (8 Lectures) 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.**

**(7 Lectures)**

**Holography: Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms.**

**(3 Lectures)**

**Suggested Reading**

Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.

Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill

Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.

Optics, Ajoy 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.

## PHY-PL2 : PHYSICS LABORATORY-II

**Total Lectures : 60** **Credits: 4**

**Max. Marks : 100**

**Objective : This course aims to impart practical knowledge to students related to the Core Papers, Mechanics, Electricity and Magnetism, and Waves and Optics, and Mathematical Physics–I.**

**Note: The Course content consists of Practicals of the Core Papers, Mechanics, Electricity and Magnetism, and Waves and Optics, and Mathematical Physics–I. The experiments will be performed by the students during the Semesters I and II. Basic experiments of these papers will be covered in Semester I and the rest will be done in Semester II. Atleast 12 experiments, taking atleast Two from each of the Sections I-IV are to be performed in each Semester without repetition. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.**

### SECTION – I

### MECHANICS (PRACTICALS)

**Objective: The laboratory exercises in this section have been so designed that the students learn to verify some of the concepts learnt in the theory courses. They are trained in carrying out precise measurements and handling sensitive equipments.**

1. Use of Vernier callipers, Screw gauge, Spherometer, Barometer, Sphygmomanometer, Lightmeter, dry and wet thermometers, TDS/conductivity meter and other measuringinstruments based on applications of the experiments. Use of Plumb line and Spirit level.
2. To study the random error in observations.
3. Determination of height (of inaccessible structure) using sextant.
4. To study the Motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
5. To determine the Moment of Inertia of a Flywheel.
6. To determine g and velocity for a freely falling body using Digital Timing Technique
7. To determine the value of g using Kater's Pendulum.
8. To study the variation of time period with distance between centre of suspension and centre of gravity for a bar pendulum and to determine: (i) Radius of gyration of the bar about an axis

**through its C.G. and perpendicular to its length. (ii) The value of g in the laboratory.**

9. **Determination of coefficient of viscosity of a given liquid by Stoke's method. Study its temperature dependence.**
10. **To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).**
11. **To determine the Young's Modulus of a Wire by Optical Lever Method.**
12. **To determine the Young's modulus by (i) bending of beam using traveling microscope/laser, (ii) Flexural vibrations of a bar.**
13. **Determination of modulus of rigidity by (i) dynamic method Maxwell's needle/Torsional pendulum; (ii) Forced torsional oscillations excited using electromagnet.**
14. **To determine the elastic Constants of a wire by Searle's method.**
15. **To study one dimensional collision using two hanging spheres of different materials.**

## SECTION – II

## ELECTRICITY AND MAGNETISM (PRACTICALS)

**Objective: The aim of this section of the course is to build an understanding about various components of an electrical circuit and to develop skill to measure the related physical quantities.**

1. **Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.**
2. **To determine an unknown Low Resistance using Potentiometer.**
3. **To determine an unknown Low Resistance using Carey Foster's Bridge.**
4. **Measurement of field strength B and its variation in a solenoid (determine dB/dx)**
5. **To determine the value of an air capacitance by de-Sauty Method and to find permittivity of air. Also to determine the dielectric constant of a liquid.**
6. **To verify the Thevenin and Norton theorems.**
7. **To verify the Superposition, and Maximum power transfer theorems.**
8. **To determine self inductance of a coil by Anderson's bridge.**
9. **To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.**
10. **To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.**

11. **Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer**
12. **Determine a high resistance by leakage method using Ballistic Galvanometer.**
13. **To determine self-inductance of a coil by Rayleigh's method.**
14. **To determine the mutual inductance of two coils by Absolute method.**
15. **Determination of E.C.E. of hydrogen and evaluation of Faraday and Avogadro constants.**
16. **To study the magnetic field produced by a current carrying solenoid using a pick-up coil/Hall sensor and to find the value of permeability of air.**
17. **To determine the frequency of A.C. mains using sonometer.**
18. **To determine the resistance of an electrolyte for A.C current and study its concentration dependence. Also to study temperature dependence.**
19. **Study of temperature dependence resistivity of Cu conductor, Manganin/constantin alloy and semiconductor (FET channel).**
20. **To measure thermo e.m.f. of a thermocouple as a function of temperature and find inversion temperature.**
21. **To study C.R.O. as display and measuring device by recording sines and square waves, output from a rectifier, verification (qualitative) of law of electromagnetic induction and frequency of A.C. mains.**
22. **To plot the Lissajous figures and determine the phase angle by C.R.O.**
23. **To study B-H curves for different ferromagnetic materials using C.R.O.**
24. **Determination of low inductance by Maxwell-Wein bridge.**
25. **Study of R.C. circuit with a low frequency a.c. source.**
26. **Studies based on LCR Board: Impedance of LCR circuit and the phase and between voltage and current.**

## SECTION – III

## WAVES AND OPTICS (PRACTICALS)

**Objective: The course content in this section covers experiments related to damped, driven and forced oscillations, wave motion in media. Properties and Characteristics of light through experiments related to interference and diffraction phenomenon are high lighted.**

1. **To determine the frequency of an electric tuning fork by Melde's experiment and verify $\lambda^2$ –T law.**
2. **To investigate the motion of coupled oscillators.**

3. To study Lissajous Figures.
4. Familiarization with: Schuster`s focusing; determination of angle of prism.
5. To determine refractive index of the Material/liquid of a prism using sodium source.
6. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
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 (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
12. To determine dispersive power and resolving power of a plane diffraction grating.
13. To study Malus's law of polarization.
14. To find the resolving power and magnification of a telescope.
15. To find the resolving power and magnification of a diffraction grating.
16. To study hydrogen/Neon gas discharge tube spectrum using diffraction grating.
17. To study temperature dependence of refractive index of organic liquid using Abbe's refractometer.
18. To study the variation of specific rotation of sugar solution with concentration.
19. To measure power distribution and divergence parameters of He-Ne and Semiconductor lasers.
20. To study Moire's fringe patterns and applications to measure small distance and angle.

## SECTION – IV

## MATHEMATICAL PHYSICS-I (PRACTICALS)

Objective: The aim of this section of Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.

Highlights the use of computational methods to solve physical problems

The course will consist of lectures (both theory and practical) in the Lab

Evaluation done not on the programming but on the basis of formulating the problem

Aim at teaching students to construct the computational problem to be solved

Students can use any one operating system Linux or Microsoft Windows

| Topics | Description with Applications |
| --- | --- |
| Introduction and Overview | Computer architecture and organization, memory and Input/output devices |
| Basics of scientific computing | Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow- emphasize the importance of making equations in terms of dimensionless variables, Iterative methods |
| Errors and error Analysis | Truncation and round off errors, Absolute and relative errors, Floating point computations. |
| Review of C & C++ Programming fundamentals | Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulatorsfordataformatting,Control statements(decisionmakingandlooping statements) (If statement. If else Statement. Nested if Structure. Else-if Statement. Ternary Operator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops), Arrays (1D & 2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects. |
| Programs: | Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search |
| Random number generation | Area of circle, area of square, volume of sphere, value of pi (π) |

| | |
|---|---|
| Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods | Solution of linear and quadratic equation, solving α =tanα ; $I = I_0 \left[\frac{\sin \alpha}{\alpha}\right]^2$ in optics |
| Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation | Evaluation of trigonometric functions e.g. sin θ, cos θ, tan θ etc. |
| Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method | Given Position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of B-H Hysteresis loop |
| Solution of Ordinary Differential Equations (ODE)<br>First order Differential equation Euler, modified Euler and Runge-Kutta (RK) second and fourth order methods | First order differential equation<br>• Radioactive decay<br>• Current in RC, LC circuits with DC source<br>• Newton's law of cooling<br>• Classical equations of motion<br>Attempt following problems using RK 4 order method:<br>Solve the coupled differential equations<br>$\frac{dx}{dt} = y + x - \frac{x^3}{3}; \ \frac{dy}{dt} = -x$<br>for four initial conditions<br>x(0) = 0, y(0) = -1, -2, -3, -4.<br>Plot x vs y for each of the four initial conditions on the same screen for 0 ≤ t ≤ 15<br>The differential equation describing the motion of a pendulum is $\frac{d^2\theta}{dt^2} = -\sin\theta$. The pendulum is released from rest at an angular displacement α and θ'(0) = 0. Solve the equation for α = 0.1, 0.5 and 1.0 and plot θ as a function of time in the range 0 ≤ t ≤ 8π. Also plot the analytic solution valid for small θ (sin θ = θ) |

**Suggested Reading (Sections - I, II, III)**

1. 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

A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal

Engineering Practical Physics, S. Panigrahi & B.Mallick, 2015, Cengage Learning India Pvt. Ltd.

Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.

A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

**Suggested Reading (Section - IV)**

Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.

Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw - Hill Pub.

Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rd Edn. , 2007, Cambridge University Press.

A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.

Elementary Numerical Analysis, K.E. Atkinson, 3rd 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.

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# Generic Elective Papers (GE) (Minor-Physics) for Physical Sciences and Bio-Medical Sciences Departments/Disciplines

## PHY-C-GE1 ELECTRICITY AND MAGNETISM

## PHY-C-GE1 (T) : ELECTRICITY AND MAGNETISM THEORY

**Total Lectures : 60** **Credits: 4**

**Max. Marks : 100**

**Objective : This course focuses on essentials of electrostatics and magnetostatics along with Maxwell's mathematical formulation of electric and magnetic fields.**

**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). **(12 Lectures)**

**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 field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric. **(22 Lectures)**

**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. (10 Lectures)

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 magnetic field. (6 Lectures)

Maxwell`s equations and Electromagnetic wave propagation: Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, polarization. (10 Lectures)

**Suggested Reading**

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

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## PHY-C-GE1(P) : ELECTRICITY AND MAGNETISM PRACTICAL

**Total Lectures: 60** **Credits: 2**

**Max. Marks : 50**

Objective : This course aims to impart practical knowledge to students related to the Generic Elective Physics subjects with in particular emphasis on Electricity and Magnetism.

**Note:** The experiments listed in the Practical Part of the Generic Elective Physics subject, i.e., Electricity and Magnetism, Mechanics, Thermal Physics, Elements of Modern Physics. The experiments will be performed by the students during the Semesters I and II. Basic experiments of these papers will be covered in Semester I and the rest will be done in Semester II. Atleast 8 experiments are to be performed in each Semester without repetition. General evaluation procedure has been defined under the heading “Evaluation” in the beginning of the syllabus.

## SECTION-I

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (b) DC Current, and (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 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 calibrate the wire of Carey Foster bridge and hence determine Low Resistance of two turns of a tangent galvanometer.
9. To verify the Thevenin and Norton theorems
10. To verify the Superposition, and Maximum Power Transfer Theorems
11. Self-inductance by Anderson's bridge.
12. Verification of laws of electromagnetic induction.
13. Verification of maximum power theorem.
14. To study the concentration dependence of the resistance electrolyte
15. To study dependence of magnetic field in a solenoid on various parameters and hence to evaluate $\mu_0$.
16. To study the variation of the resistance of filament of bulb with its temperature.
17. Study of B-H curves of various materials using C.R.O, and determination of various parameters.

## SECTION-II

1. Use of Vernier callipers, Screw gauge, Spherometer, Barometer, Sphygmomanometer, Lightmeter, dry and wet thermometers, TDS/conductivity meter and other measuringinstruments based on applications of the experiments. Use of Plumb line and Spirit level.
2. Determination of height (of inaccessible structure) using sextant.
3. To determine the Moment of Inertia of a Flywheel.
4. To study the variation of time period with distance between centre of suspension and centre of

gravity for a bar pendulum and to determine: (i) Radius of gyration of the bar about an axis through its C.G. and perpendicular to its length. (ii) The value of g in the laboratory.

5. Determination of coefficient of viscosity of a given liquid by Stoke's method. Study its temperature dependence.
6. To determine the Young's modulus by bending of beam using traveling microscope/laser.
7. Determination of modulus of rigidity by (i) dynamic method Maxwell's needle/Torsional pendulum; (ii) Forced torsional oscillations excited using electromagnet.

## SECTION-III

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

## SECTION-IV

1. To determine value of Boltzmann constant using V-I characteristic of PN diode.
2. To determine work function of material of filament of directly heated vacuum diode.
3. To determine the ionization potential of mercury.
4. To determine value of Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the absorption lines in the rotational spectrum of Iodine vapour.
7. To study the diffraction patterns of single and double slits using laser and measure its intensity

variation using Photosensor & compare with incoherent source – Na.

8. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light.
9. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
10. To setup the Millikan oil drop apparatus and determine the charge of an electron.
11. Determination of Eg in Si and Ge.
12. Determination of Planck's constant using photocell.
13. Dependence of scattering angle on kinetic energy and impact parameter in Rutherford scattering (mechanical analogue).
14. Verification of Rutherford- Soddy nuclear decay formula - mechanical analogue.
15. To find half-life period of a given radio-active substance using GM counter/ Charterctisitcs of GM Counter.

## Suggested reading

Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.

Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed.2011, Kitab Mahal

Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd.

A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal, 1985, Vani Publication.

Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.

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## PHY-C-GE2 ELEMENTS OF MODERN PHYSICS

## PHY-C-GE2 (T) : ELEMENTS OF MODERN PHYSICS THEORY

**Total Lectures: 60** **Credits: 4**

**Max. Marks: 100**

**Objective: The aim of the course is to provide students with insight of the exciting results and reasoning of the physical phenomena on the basis of modern physcs.**

**Planck's quantum, Planck's constant and light as a collection of photons; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. (8 Lectures)**

**Problems with Rutherford model- instability of atoms and observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; calculation of energy levels for hydrogen like atoms and their spectra. (4 Lectures)**

**Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle. (4 Lectures)**

**Two slit interference experiment with photons, atoms & particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wavefunction, probabilities and normalization; Probability and probability current densities in one dimension. (11 Lectures)**

**One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunnelling in one dimension - across a step potential and across a rectangular potential barrier. (12 Lectures)**

**Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, semi-empirical mass formula and binding energy. (6 Lectures)**

**Radioactivity: stability of nucleus; Law of radioactive decay; Mean life and half-life; α decay; β decay - energy released, spectrum and Pauli's prediction of neutrino; γ-ray emission. (11 Lectures)**

**Fission and fusion - mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions. (4 Lectures)**

## Suggested Reading


1. **Concepts of Modern Physics, Arthur Beiser, 2009, McGraw-Hill**
2. **Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson,2009, PHI Learning**
3. **Six Ideas that Shaped Physics:Particle Behave like Waves, Thomas A. Moore, 2003, McGraw Hill**
4. **Quantum Physics, Berkeley Physics,Vol.4. E.H. Wichman, 2008, Tata McGraw-Hill Co.**
5. **Modern Physics, R.A. Serway, C.J. Moses, and C.A.Moyer, 2005, Cengage Learning**
6. **Modern Physics, G. Kaur and G.R. Pickrell, 2014, McGraw Hill**


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## PHY-C-GE2 (P) : ELEMENTS OF MODERN PHYSICS PRACTICAL

**Total Lectures : 60** **Credits: 2**

**Max. Marks : 50**

**Objective : This course aims to impart practical knowledge to students related to the Generic Elective Physics subjects with in particular emphasis on Modern Physics.**

**Note: The experiments listed in the Practical Part of the Generic Elective Physics subject, i.e., Electricity and Magnetism, Mechanics, Thermal Physics, Elements of Modern Physics. The experiments will be performed by the students during the Semesters I and II. Basic experiments of these papers will be covered in Semester I and the rest will be done in Semester II. Atleast 8 experiments are to be performed in each Semester without repetition. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.**

## SECTION-I

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (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 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 calibrate the wire of Carey Foster bridge and hence determine Low Resistance of two turns of a tangent galvanometer.
9. To verify the Thevenin and Norton theorems
10. To verify the Superposition, and Maximum Power Transfer Theorems
11. Self-inductance by Anderson's bridge.
12. Verification of laws of electromagnetic induction.
13. Verification of maximum power theorem.
14. To study the concentration dependence of the resistance electrolyte
15. To study dependence of magnetic field in a solenoid on various parameters and hence to evaluate $\mu_0$.
16. To study the variation of the resistance of filament of bulb with its temperature.
17. Study of B-H curves of various materials using C.R.O, and determination of various parameters.

## SECTION-II

1. Use of Vernier callipers, Screw gauge, Spherometer, Barometer, Sphygmomanometer, Lightmeter, dry and wet thermometers, TDS/conductivity meter and other measuringinstruments based on applications of the experiments. Use of Plumb line and Spirit level.
2. Determination of height (of inaccessible structure) using sextant.
3. To determine the Moment of Inertia of a Flywheel.
4. To study the variation of time period with distance between centre of suspension and centre of

gravity for a bar pendulum and to determine: (i) Radius of gyration of the bar about an axis through its C.G. and perpendicular to its length. (ii) The value of g in the laboratory.

5. Determination of coefficient of viscosity of a given liquid by Stoke's method. Study its temperature dependence.
6. To determine the Young's modulus by bending of beam using traveling microscope/laser.
7. Determination of modulus of rigidity by (i) dynamic method Maxwell's needle/Torsional pendulum; (ii) Forced torsional oscillations excited using electromagnet.

## SECTION-III

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

## SECTION-IV

1. To determine value of Boltzmann constant using V-I characteristic of PN diode.
2. To determine work function of material of filament of directly heated vacuum diode.
3. To determine the ionization potential of mercury.
4. To determine value of Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the absorption lines in the rotational spectrum of Iodine vapour.
7. To study the diffraction patterns of single and double slits using laser and measure its intensity

variation using Photosensor & compare with incoherent source – Na.

8. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light.
9. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
10. To setup the Millikan oil drop apparatus and determine the charge of an electron.
11. Determination of Eg in Si and Ge.
12. Determination of Planck's constant using photocell.
13. Dependence of scattering angle on kinetic energy and impact parameter in Rutherford scattering (mechanical analogue).
14. Verification of Rutherford- Soddy nuclear decay formula - mechanical analogue.
15. To find half-life period of a given radio-active substance using GM counter/ Charterctisitcs of GM Counter.

## Suggested reading

Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.

Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed.2011, Kitab Mahal

Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd.

A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal, 1985, Vani Publication.

Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.

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## Semester III

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## PHY-C5: MATHEMATICAL PHYSICS-II

## PHY-C5 (T): MATHEMATICAL PHYSICS-II (THEORY)

**Total Lectures : 60** **Credits: 4**

**Max. Marks : 100**

**Objective : The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined on the basis of problems, seen and unseen.**

**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. (10 Lectures)**

**Frobenius Method and Special Functions: Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations. 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 ($J_o(x)$ and $J_1(x)$)and Orthogonality.**

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

**Theory of Errors: Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. Least-squares fit. Error on the slope and intercept of a fitted line. (6 Lectures) 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. (14 Lectures)

**Reference Books:**

Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier. Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.

Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.

Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.

Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.

Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press

Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books

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## PHY-C5 (P): MATHEMATICAL PHYSICS-II

## PRACTICALS

**Total Lectures : 30** **Credits: 2**

**Max. Marks : 50**

**Objective:** The aim of this Lab is to use the computational methods to solve physical problems. Course will consist of lectures (both theory and practical) in the Lab. Evaluation done not on the programming but on the basis of formulating the problem.

**Note:** The experiments listed in the Practical Part of the Core Papers, i.e., PHY-C5 (P): Mathematical Physics - II, PHY-C6 (P): Thermal Physics, PHY- C7 (P): Digital Systems and Applications, PHY- C8 (P): Mathematical Physics - III, PHY- C9 (P): Elements of Modern Physics, PHY- C10 (P): Analog Systems and Applications, are to be clubbed together and will be performed by the students during the Semesters I and II. Basic experiments of these core papers will be covered in Semester I and the rest will be done in Semester II. 20 experiments are to be performed in each Semester without any repetition. General evaluation procedure has been defined under the heading “Evaluation” in the beginning of the syllabus.

| Topics | Description with Applications |
|---|---|
| Introduction to Numerical computation software Scilab | Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting, 2D and 3D plotting (2), Branching Statements and program design, Relational & logical operators, the while loop, for loop, details of loop operations, break & continue statements, nested loops, logical arrays and vectorization (2) User defined functions, Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays (2) an introduction to Scilab file processing, file opening and closing, Binary I/O functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program (2). |
| Curve fitting, Least square fit, Goodness of fit, standard deviation | Ohms law to calculate R, Hooke's law to calculate spring constant |
| Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalization of | Solution of mesh equations of electric circuits (3 meshes); Solution of coupled spring mass systems (3 masses) |

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|---|---|
| matrices, Inverse of a matrix, Eigen vectors, eigen values problems | |
| Generation of Special functions using User defined functions in Scilab | Generating and plotting Legendre Polynomials<br>Generating and plotting Bessel function |
| Solution of ODE<br>First order Differential equation Euler, modified Euler and Runge-Kutta second order methods<br>Second order differential equation<br>Fixed difference method | First order differential equation<br>Radioactive decay<br>Current in RC, LC circuits with DC source<br>Newton's law of cooling<br>Classical equations of motion<br>Second order Differential Equation<br>Harmonic oscillator (no friction)<br>Damped Harmonic oscillator<br>Over damped<br>Critical damped<br>Oscillatory<br>Forced Harmonic oscillator<br>Transient and<br>Steady state solution<br>Apply above to LCR circuits also<br>Solve<br>$x^2\frac{d^2y}{dx^2} - 4x(1+x)\frac{dy}{dx} + 2(1+x)y = x^3$<br>with the boundary conditions at<br>$x = 1, y = \frac{1}{2}e^2, \frac{dy}{dx} = e^2$- 0.5,<br>In the range 1 x 3. Plot y and $\frac{dy}{dx}$<br>against x in the given range on the same graph. |
| Partial differential equations | Partial Differential Equation:<br>Wave equation<br>Heat equation |

| | |
|---|---|
| | Poisson equation<br>Laplace equation |
| Using Scicos / xcos | Generating square wave, sine wave, saw tooth wave<br>Solution to harmonic oscillator<br>Study of beat phenomenon<br>Phase space plots |

**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 & M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press

First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett

Computational Physics, D.Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.

A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press

Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernández. 2014 Springer

Scilab by example: M. Affouf 2012, ISBN: 978-1479203444

Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand & Company

Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing www.scilab.in/textbook_companion/generate_book/291


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## PHY-C6: THERMAL PHYSICS

## PHY-C6 (T) : THERMAL PHYSICS

## THEORY

**Total Lectures : 60** **Credits: 4**

**Max. Marks : 100**

**Objective: The covers laws of thermodynamics and applications, Thermodynamic Potentials, Maxwell's Thermodynamic Relations, Kinetic theory of gases, molecular collisions and real gas behaviour, Equation of State for Real Gases, Joule-Thomson Effect for Real and Van der Waal Gases.**

### Introduction to Thermodynamics

**Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between $C_P$ and $C_V$, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient. (8 Lectures)**

**Second 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 & efficiency. Refrigerator & coefficient of performance, $2^{nd}$ Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale. (10 Lectures)**

**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. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero. (7 Lectures)**

**Thermodynamic Potentials: Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron**

**Equation and Ehrenfest equations. (7 Lectures) Maxwell's Thermodynamic Relations: Derivations and applications of Maxwell's Relations,**

**Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Values of $C_p$-$C_v$, (3) TdS Equations,**

**(4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process.**
**(7 Lectures)**

**Kinetic Theory of Gases**

**Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases.**
**(7 Lectures)**

**Molecular Collisions: Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance.**
**(4 Lectures)**

**Real Gases: Behavior 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 Waal's 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. (10 Lectures)**

**Reference Books:**

**Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill. A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press nd**

**Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.**

**Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.**

**Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press**

**Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.**

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## PHY-C6 (P) : THERMAL PHYSICS

## PRACTICALS

**Total Lectures : 60** **Credits: 2**

**Max. Marks : 50**

**Objective: The laboratory exercises have been so designed on measurements of thermal conductivity, Temperature Coefficient of Resistance,and use of various temperature transducers.**

**Note: The experiments listed in the Practical Part of the Core Papers, i.e., PHY-C5 (P): Mathematical Physics - II, PHY-C6 (P): Thermal Physics, PHY- C7 (P): Digital Systems and Applications, PHY- C8 (P): Mathematical Physics - III, PHY- C9 (P): Elements of Modern Physics, PHY- C10 (P): Analog Systems and Applications, are to be clubbed together and will be performed by the students during the Semesters I and II. Basic experiments of these core papers will be covered in Semester I and the rest will be done in Semester II. 20 experiments are to be performed in each Semester without any repetition. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.**

27. **To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.**
28. **To measure the coefficient of linear expansion for different metals and alloys.**
29. **To determine the value of Stefan's Constant of radiation.**
30. **To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.**
31. **To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.**
32. **To measure the thermal conductivity and thermal diffusivity of a conductor.**
33. **To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.**
34. **To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).**
35. **To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions. To calibrate a thermocouple to measure temperature in a specified Range using (i) Null Method, (ii) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.**
36. **To determine thermal conductivity of a bad conductor disc using Advance kit involving constant current source for heating and thermocouples for temperature measurements.**

**Reference Books**

20. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House

21. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal

22. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

23. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal,1985, Vani Pub.

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## PHY-C7: DIGITAL SYSTEMS AND APPLICATIONS PHY-C7 (T): DIGITAL SYSTEMS AND APPLICATIONS THEORY

**Total Lectures : 60** **Credits: 4**

**Objective:** The course covers CRO, basics of integrated circuit technology, binary arithmetic, Logic gates, sequential and combinational circuits, Timers and counters, Microprocessor basics, Computer organization.

**Introduction to CRO:** Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference. (3 Lectures)

**Integrated Circuits (Qualitative treatment only):** Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital ICs. (3 Lectures)

**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. (6 Lectures)

**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 (1) Sum of Products Method and (2) Karnaugh Map. (6 Lectures) Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.

Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor. (5 Lectures)

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: IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator. (3 Lectures)

Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits). (2 Lectures)

Counters(4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous (4 Lectures)

Computer Organization: Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map. (6 Lectures)

Intel 8085 Microprocessor Architecture: Main features of 8085. Block diagram. Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing & Control circuitry. Timing states. Instruction cycle, Timing diagram of MOV and MVI. (8 Lectures)

Introduction to Assembly Language: 1 byte, 2 byte & 3 byte instructions. (4 Lectures)

Reference Books:

Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw

Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 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 & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning

Logic circuit design, Shimon P. Vingron, 2012, Springer.

Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.

Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill

Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

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## PHY-C7 (P): DIGITAL SYSTEMS AND APPLICATIONS

## PRACTICALS

**Total Lectures : 60** **Credits: 2**

**Objective: The laboratory exercises have been so designed that the students learn to verify some of the concepts learnt in the theory course of digital electronics. It covers practical training on basic Logic gates, flip-flops, sequential and combinational circuits, Timers and counters, Assembly language programming of 8085 Microprocessor.**

**Note: The experiments listed in the Practical Part of the Core Papers, i.e., PHY-C5 (P): Mathematical Physics - II, PHY-C6 (P): Thermal Physics, PHY- C7 (P): Digital Systems and Applications, PHY- C8 (P): Mathematical Physics - III, PHY- C9 (P): Elements of Modern Physics, PHY- C10 (P): Analog Systems and Applications, are to be clubbed together and will be performed by the students during the Semesters I and II. Basic experiments of these core papers will be covered in Semester I and the rest will be done in Semester II. 20 experiments are to be performed in each Semester without any repetition. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.**

- **To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.**
- **To test a Diode and Transistor using a Multimeter.**
- **To design a switch (NOT gate) using a transistor.**
- **To verify and design AND, OR, NOT and XOR gates using NAND gates.**
- **To design a combinational logic system for a specified Truth Table.**
- **To convert a Boolean expression into logic circuit and design it using logic gate ICs.**
- **To minimize a given logic circuit.**
- **Half Adder, Full Adder and 4-bit binary Adder.**
- **Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.**
- **To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.**
- **To build JK Master-slave flip-flop using Flip-Flop ICs**
- **To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.**
- **To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.**
- **To design an astable multivibrator of given specifications using 555 Timer.**
- **To design a monostable multivibrator of given specifications using 555 Timer.**
- **Write the following programs using 8085 Microprocessor**

1. **Addition and subtraction of numbers using direct addressing mode**

7. Addition and subtraction of numbers using indirect addressing mode
8. Multiplication by repeated addition.
9. Division by repeated subtraction.
10. Handling of 16-bit Numbers.
11. Use of CALL and RETURN Instruction.
12. Block data handling.
13. Other programs (e.g. Parity Check, using interrupts, etc.).

**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, M.A. Miller, 1994, Mc-Graw Hill.

Microprocessor Architecture Programming and applications with 8085, R.S. Goankar, 2002, Prentice Hall.

Microprocessor 8085:Architecture, Programming and interfacing, A. Wadhwa, 2010, PHI Learning.

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## Semester IV

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## PHY-C8: MATHEMATICAL PHYSICS-III

## PHY-C8 (T): MATHEMATICAL PHYSICS-III (THEORY)

**Total Lectures : 60** **Credits: 4**

**Max. Marks : 100**

**Objective : The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined on the basis of problems, seen and unseen.**

**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 region. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integrals.** **(30 Lectures)**

### Integrals Transforms:

**Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function 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.** **(15 Lectures)**

**Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs:**

**st nd**

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 $2^{nd}$ order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of $1^{st}$ order. Solution of heat flow along infinite bar using Laplace transform. (15 Lectures)

**Reference Books:**

Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, $3^{rd}$ ed., 2006, Cambridge University Press

Mathematics for Physicists, P. Dennery and A.Krzywicki, 1967, Dover Publications

Complex Variables, A.S.Fokas & M.J.Ablowitz, $8^{th}$ Ed., 2011, Cambridge Univ. Press Complex Variables, A.K. Kapoor, 2014, Cambridge Univ. Press

Complex Variables and Applications, J.W. Brown & R.V. Churchill, $7^{th}$ Ed. 2003, Tata McGraw-Hill

First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett

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## PHY-C8 (P): MATHEMATICAL PHYSICS-III (PRACTICALS)

**Total Lectures : 60** **Credits: 2**

**Max. Marks : 50**

Objective: The aim of this Lab is to use the computational methods to solve physical problems. Course will consist of lectures (both theory and practical) in the Lab. Evaluation done not on the programming but on the basis of formulating the problem.

Note: The experiments listed in the Practical Part of the Core Papers, i.e., PHY-C5 (P): Mathematical Physics - II, PHY-C6 (P): Thermal Physics, PHY- C7 (P): Digital Systems and Applications, PHY- C8 (P): Mathematical Physics - III, PHY- C9 (P): Elements of Modern Physics, PHY- C10 (P): Analog Systems and Applications, are to be clubbed together and will be performed by the students during the Semesters I and II. Basic experiments of these core papers will be covered in Semester I and the rest will be done in Semester II. 20 experiments are to be performed in each Semester without any repetition. General evaluation procedure has been defined under the heading “Evaluation” in the beginning of the syllabus.

Scilab/C++ based simulations experiments based on Mathematical Physics problems like

9. **Solve differential equations:**

   $dy/dx = e^{-x}$ with $y = 0$ for $x = 0$

   $dy/dx + e^{-x} y = x^2$

   $d^2y/dt^2 + 2\, dy/dt = -y$

   $d^2y/dt^2 + e^{-t}\, dy/dt = -y$

10. **Dirac Delta Function :** Evaluate $\frac{1}{\sqrt{2\pi\sigma^2}}\int e^{\frac{-(x-2)^2}{2\sigma^2}}(x+3)dx,$ for = 1, 0.1, 0.01 and show it tends to 5.

11. **Fourier Series:**

    Program to sum $\sum_{n=1}^{\infty}(0.2)^n$

    Evaluate the Fourier coefficients of a given periodic function (square wave)

12. **Frobenius method and Special functions:**

    $$\int_{-1}^{+1} P_n(\mu)P_m(\mu)d\mu = \delta_{n,m}$$

    Plot $P_n(x)$, j (x).

    Show recursion relations.

13. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).

14. Calculation of least square fitting manually without giving weightage to error.

    Confirmation of least square fitting of data through computer program.

15. Evaluation of trigonometric functions e.g. sin θ, Given Bessel's function at N points find its value at an intermediate point. Complex analysis: Integrate $1/(x^2+2)$ numerically and check with computer integration.

16. Compute the $n^{th}$ roots of unity for n = 2, 3, and 4.

17. Find the two square roots of −5+12j.

18. Integral transform: FFT of

19. Solve Kirchoff's Current law for any node of an arbitrary circuit using Laplace's

transform.

8. Solve Kirchoff's Voltage law for any loop of an arbitrary circuit using Laplace's transform.
9. Perform circuit analysis of a general LCR circuit using Laplace's transform.

**Reference Books:**

Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press

Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications

Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896

A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn.,

Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444

Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand & Company

Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing

https://web.stanford.edu/~boyd/ee102/laplace_ckts.pdf

ocw.nthu.edu.tw/ocw/upload/12/244/12handout.pdf

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## PHY-C9: ELEMENTS OF MODERN PHYSICS PHY-C9 (T): ELEMENTS OF MODERN PHYSICS THEORY

**Total Lectures : 60** **Credits: 4**

**Max. Marks : 100**

**Objective :** The course content covers foundations of modern physics, experiments forming basis of quantum mechanics, Schrodinger equation and applications, uncertainty principle, nature of nuclear force, nuclear models, fission and fusion, nuclear reactors, stellar energy Spontaneous and Stimulated emissions and Lasers.

**Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: 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. Probability. Wave amplitude and wave functions. Gravitational Red-shift of photons. (14 Lectures)**

**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. (5 Lectures)**

**Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension. (10 Lectures)**

**One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as example; Quantum mechanical scattering and tunnelling in one dimension-across a step potential & rectangular potential barrier. (10 Lectures)**

**Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers. (6 Lectures)**

**Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay- energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus. (8 Lectures)**

**Fission and fusion- mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions). (3 Lectures)**

**Lasers: 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.** **(4 Lectures)**

**Reference Books:**

**Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.**

**Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill**

**Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.**

**Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.**

**Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill**

**Quantum Mechanics: Theory & Applications, A.K.Ghatak & S.Lokanathan, 2004, Macmillan**

**Additional Books for Reference**

**Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.**

**Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.**

**Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.**

**Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.**

**Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill**

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## PHY-C9 (P): ELEMENTS OF MODERN PHYSICS PRACTICALS

**Total Lectures : 60** **Credits: 2**

**Max. Marks : 50**

**Objective : The laboratory experiments forming basis of quantum mechanics photoelectric effect – photoelectric effect, ionization potential, measurement of absorption and emission spectra, diffraction, diffraction of light, change on electron, and tunneling effect.**

**Note: The experiments listed in the Practical Part of the Core Papers, i.e., PHY-C5 (P): Mathematical Physics - II, PHY-C6 (P): Thermal Physics, PHY- C7 (P): Digital Systems and Applications, PHY- C8 (P): Mathematical Physics - III, PHY- C9 (P): Elements of Modern Physics, PHY- C10 (P): Analog Systems and Applications, are to be clubbed**

**together and will be performed by the students during the Semesters I and II. Basic experiments of these core papers will be covered in Semester I and the rest will be done in Semester II. 20 experiments are to be performed in each Semester without any repetition. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.**

10. **Measurement of Planck's constant using black body radiation and photo-detector**
11. **Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light**
12. **To determine work function of material of filament of directly heated vacuum diode.**
13. **To determine the Planck's constant using LEDs of at least 4 different colours.**
14. **To determine the wavelength of H-alpha emission line of Hydrogen atom.**
15. **To determine the ionization potential of mercury.**
16. **To determine the absorption lines in the rotational spectrum of Iodine vapour.**
17. **To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.**
18. **To setup the Millikan oil drop apparatus and determine the charge of an electron.**
19. **To show the tunneling effect in tunnel diode using I-V characteristics.**
20. **To determine (i) wavelength and (ii) angular spread of He-Ne laser using plane diffraction grating**
21. **Dependence of scattering angle on kinetic energy and impact parameter in Rutherford scattering (mechanical analogue).**
22. **Measurement of the electrical and thermal conductivity of copper to determine its Lorentz number.**
23. **To determine energy band gap of a given semiconductor.**
24. **Verification of laws of probability and radioactivity (mechanical analogue).**

**Reference Books**

2 **Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House**

3 **Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers**

4 **A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal**

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## PHY-C10: ANALOG SYSTEMS AND APPLICATIONS

## PHY-C10 (T): ANALOG SYSTEMS AND APPLICATIONS THEORY

**Total Lectures : 60** **Credits: 4**

**Max. Marks : 100**

**Objective: The course content covers basic network theorems for circuit analysis, semiconductor physics and devices, diodes and applications, bipolar junction transistors, amplifiers, feedback concepts, Operation amplifiers and applications.**

**Network theorems:** Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits. (4 Lectures)

**Semiconductor Diodes:** P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. 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. (10 Lectures)

**Two-terminal Devices and their Applications:** (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter (2) Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell. (6 Lectures)

**Bipolar Junction transistors:** n-p-n and p-n-p Transistors. 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. (6 Lectures)

**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. (10 Lectures)

**Coupled Amplifier: Two stage RC-coupled amplifier and its frequency response.** **(4 Lectures)**

Feedback in Amplifiers: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. **(4 Lectures)**

**Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators.** **(4 Lectures)**

**Operational Amplifiers (Black Box approach): Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground.** **(4 Lectures)**

**Applications of Op-Amps: (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8)** **(9 Lectures)**

**Wein bridge oscillator.**

**Conversion: Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation)** **(3 Lectures)**

**Reference Books:**


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


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## PHY-C10 (P): ANALOG SYSTEMS AND APPLICATIONS
## PRACTICALS

**Total Lectures : 60** **Credits: 2**

**Max. Marks : 50**

**Objective:** The laboratory exercises have been so designed that the students learn to study characteristics of various diodes, solar cells, and BJT and their biasing aspects, amplifiers, oscillators, ADC and DAC and OPAMP based application circuits

**Note: The experiments listed in the Practical Part of the Core Papers, i.e., PHY-C5 (P): Mathematical Physics - II, PHY-C6 (P): Thermal Physics, PHY- C7 (P): Digital Systems and Applications, PHY- C8 (P): Mathematical Physics - III, PHY- C9 (P): Elements of Modern Physics, PHY- C10 (P): Analog Systems and Applications, are to be clubbed together and will be performed by the students during the Semesters I and II. Basic experiments of these core papers will be covered in Semester I and the rest will be done in Semester II. 20 experiments are to be performed in each Semester without any repetition. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.**

3. To study I-V characteristics of different diodes - Ge, Si, LED and Zener. Use constant current source for Zener.
4. To study voltage regulation and ripple factor for a half-wave and a full-wave rectifier without and with different filters. Use of Zener diode and IC regulators.
5. To study common emitter characteristics of a given transistor and to determine various parameters.
6. Study of I-V & power curves of solar cells, and find maximum power point & efficiency.
7. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
8. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
9. To design a Wien bridge oscillator for given frequency using an op-amp.
10. To design a phase shift oscillator of given specifications using BJT.
11. To study the Colpitt`s oscillator.
12. To design a digital to analog converter (DAC) of given specifications.
13. To study the analog to digital convertor (ADC) IC.
14. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain
15. To design inverting amplifier using Op-amp (741,351) and study its frequency response
16. To design non-inverting amplifier using Op-amp (741,351) & study its frequency response

21. To study the zero-crossing detector and comparator
22. To add two dc voltages using Op-amp in inverting and non-inverting mode
23. To design a precision Differential amplifier of given I/O specification using Op-amp.
24. To investigate the use of an op-amp as an Integrator.
25. To investigate the use of an op-amp as a Differentiator.
26. To design a circuit to simulate the solution of a 1st/2nd order differential equation. \
27. To draw the characteristics of a given triode and to determine the tube parameters.
28. Calibration of a Si diode, a thermistor and thermocouple for temperature measurements.
29. To measure low resistance by Kelvin's double bridge/ Carey Foster's bridge.

**Reference Books:**

Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.

OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.

Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson

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# Skill Enhancement Course (any four) (Credit: 02 each)

# PHY-SEC1 to PHY-SEC5

## PHY-SEC1: PHYSICS ENHANCEMENT SKILLS

**Total Lectures : 30** **Credits: 2**

**Max. Marks : 50**

**Objective: The aim of this course is to enable the students to familiar and experience with various mechanical and electrical tools through hands-on mode, and to improve the abilities of the students to frame and tackle problems in Physics.**

**Note: The students in the class will be divided in to groups. There will be regular teaching of the theoretical aspects (8 hours) along with the Practical training of the students in various skill Development Subjects. Students shall submit a report of nearly 20 pages about the work done (giving details, highlighting innovation and future prospectus) by the end-semester. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.**

**Introduction: Measuring units. conversion to SI and CGS. Familiarization with meter scale, Vernier calliper, Screw gauge and their utility. Measure the dimension of a solid block, volume of cylindrical beaker/glass, diameter of a thin wire, thickness of metal sheet, etc. Use of Sextant to measure height of buildings, mountains, etc.** **(4 Lectures)**

**Mechanical Skill: Concept of workshop practice. Overview of manufacturing methods: casting, foundry, machining, forming and welding. Types of welding joints and welding defects. Common materials used for manufacturing like steel, copper, iron, metal sheets, composites and alloy, wood. Concept of machine processing, introduction to common machine tools like lathe, shaper, drilling, milling and surface machines. Cutting tools, lubricating oils. Cutting of a metal sheet using blade. Smoothening of cutting edge of sheet using file. Drilling of holes of different diameter in metal sheet and wooden block. Use of bench vice and tools for fitting. Make funnel using metal sheet.**

**(10 Lectures)**

**Electrical and Electronic Skill: Use of Multimeter. Soldering of electrical circuits having**

discrete components (R, L, C, diode) and ICs on PCB. Operation of oscilloscope. Making regulated power supply. Timer circuit, Electronic switch using transistor and relay.

(10 Lectures)

Introduction to prime movers: Mechanism, gear system, wheel, Fixing of gears with motor axel. Lever mechanism, Lifting of heavy weight using lever. braking systems, pulleys, working principle of power generation systems. Demonstration of pulley experiment. (6 Lectures)

**Reference Books:**

A text book in Electrical Technology - B L Theraja – S. Chand and Company.

Performance and design of AC machines – M.G. Say, ELBS Edn.

Mechanical workshop practice, K.C. John, 2010, PHI Learning Pvt. Ltd.

Workshop Processes, Practices and Materials, Bruce J Black 2005, 3rd Edn., Editor Newnes [ISBN: 0750660732]

New Engineering Technology, Lawrence Smyth/Liam Hennessy, The Educational Company of Ireland [ISBN: 0861674480]

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## PHY-SEC2: COMPUTATIONAL PHYSICS

**Total Lectures : 30** Credits: 2

**Max. Marks : 50**

Objective: The aim of this course is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.

Highlights the use of computational methods to solve physical problems

Use of computer language as a tool in solving physics problems (applications)

Course will consist of hands on training on the Problem solving on Computers.

**Note: The students in the class will be divided in to groups. There will be regular teaching of the theoretical aspects (8 hours) along with the Practical training of the students in various skill Development Subjects. Students shall submit a report of nearly 20 pages about the work done (giving details, highlighting innovation and future prospectus) by the end-semester. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.**

**Introduction: Importance of computers in Physics, paradigm for solving physics problems for solution. Usage of linux as an Editor. Algorithms and Flowcharts: Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin(x) as a series, algorithm for plotting (1) lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal. (4 Lectures)**

**Scientific Programming: Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN, Basic elements of FORTRAN: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems.**

**(5 Lectures)**

**Control Statements: Types of Logic (Sequential, Selection, Repetition), Branching Statements (Logical IF, Arithmetic IF, Block IF, Nested Block IF, SELECT CASE and ELSE IF Ladder statements), Looping Statements (DO-CONTINUE, DO-ENDDO, DO-WHILE, Implied and Nested DO Loops), Jumping Statements (Unconditional GOTO, Computed GOTO, Assigned GOTO) Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN, CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems.**

**Programming:**

1. **Exercises on syntax on usage of FORTRAN**
2. **Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN.**
3. **To print out all natural even/ odd numbers between given limits.**

7. To find maximum, minimum and range of a given set of numbers.

5. Calculating Euler number using exp(x) series evaluated at x=1 (6 Lectures)

Scientific word processing: Introduction to LaTeX: TeX/LaTeX word processor, preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages. Equation representation: Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors. (6 Lectures) Visualization: Introduction to graphical analysis and its limitations. Introduction to Gnuplot. importance of visualization of computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot.

Hands on exercises:

9. To compile a frequency distribution and evaluate mean, standard deviation etc.
10. To evaluate sum of finite series and the area under a curve.
11. To find the product of two matrices
12. To find a set of prime numbers and Fibonacci series.
13. To write program to open a file and generate data for plotting using Gnuplot.
14. Plotting trajectory of a projectile projected horizontally.
15. Plotting trajectory of a projectile projected making an angle with the horizontally.
16. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen. Saving it as an eps file and as a pdf file.
17. To find the roots of a quadratic equation.
18. Motion of a projectile using simulation and plot the output for visualization.
19. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.
20. Motion of particle in a central force field and plot the output for visualization.

(9 Lectures)

**Reference Books:**

Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
Computer Programming in Fortran 77". V. Rajaraman (Publisher: PHI).
LaTeX–A Document Preparation System", Leslie Lamport (Second Edition, Addison-Wesley, 1994).
Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010)
Schaum's Outline of Theory and Problems of Programming with Fortran, S Lipsdutz and A Poe, 1986Mc-Graw Hill Book Co.
Computational Physics: An Introduction, R. C. Verma et al. New Age International Publishers, New Delhi(1999)
A first course in Numerical Methods, U.M. Ascher and C. Greif, 2012, PHI Learning
Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition.

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## PHY-SEC3: ELECTRICAL CIRCUITS AND NETWORK SKILLS

**Total Lectures : 30** Credits: 2
**Max. Marks : 50**

**Objective: The aim of this course is to enable the students to design and trouble shoots the electrical circuits, networks and appliances through hands-on mode**

**Note: The students in the class will be divided in to groups. There will be regular teaching of the theoretical aspects (8 hours) along with the Practical training of the students in various skill Development Subjects. Students shall submit a report of nearly 20 pages about the work done (giving details, highlighting innovation and future prospectus) by the end-semester. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.**

Basic Electricity Principles: Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC Electricity and DC Electricity. Familiarization with multimeter, voltmeter and ammeter. (3 Lectures)

**Understanding Electrical Circuits:** 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 and three-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. (4 Lectures)

**Electrical Drawing and Symbols:** Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop.

(4 Lectures)

**Generators and Transformers:** DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers. (3 Lectures)

**Electric Motors:** Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters & motors. Speed & power of ac motor. (4 Lectures) **Solid-State Devices:** Resistors, inductors and capacitors. Diode and rectifiers.Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources.

(3 Lectures)

**Electrical Protection:** 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)

(4 Lectures)

**Electrical Wiring:** 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. Conduit. Cable trays. Splices: wirenuts, crimps, terminal blocks, split bolts, and solder. Preparation of extension board. (5 Lectures)

**Reference Books:**

A text book in Electrical Technology - B L Theraja - S Chand & Co. A text book of Electrical Technology - A K Theraja

Performance and design of AC machines - M G Say ELBS Edn.

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## PHY-SEC4: BASIC INSTRUMENTATION SKILLS

**Total Lectures : 30** **Credits: 2**

**Max. Marks : 50**

**Objective: This course is to get exposure with various aspects of instruments and their usage through hands-on mode. Experiments listed below are to be done in continuation of the topics.**

**Note: The students in the class will be divided in to groups. There will be regular teaching of the theoretical aspects (8 hours) along with the Practical training of the students in various skill Development Subjects. Students shall submit a report of nearly 20 pages about the work done (giving details, highlighting innovation and future prospectus) by the end-semester. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.**

**Basic of Measurement: Instruments 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. (4 Lectures)**

**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. AC millivoltmeter: Type of AC millivoltmeters: Amplifier- rectifier, and rectifier- amplifier. Block diagram ac millivoltmeter, specifications and their significance. (4 Lectures)**

**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 & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance. (6 Lectures)**

**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. (3 Lectures)**

**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. (4 Lectures)

Impedance Bridges & Q-Meters: Block diagram of bridge. working principles of basic (balancing type) RLC bridge. Specifications of RLC bridge. Block diagram & working principles of a Q- Meter. Digital LCR bridges. (3 Lectures)

Digital Instruments: Principle and working of digital meters. Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter.

(3 Lectures)

Digital Multimeter: Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/ frequency counter, time- base stability, accuracy and resolution. (3 Lectures)

The test of lab skills will be of the following test items:

6. Use of an oscilloscope.
7. CRO as a versatile measuring device.
8. Circuit tracing of Laboratory electronic equipment,
9. Use of Digital multimeter/VTVM for measuring voltages
10. Circuit tracing of Laboratory electronic equipment
11. Winding a coil / transformer.
12. Study the layout of receiver circuit.
13. Trouble shooting a circuit
14. Balancing of bridges

Laboratory Exercises:

2. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
3. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
4. To measure Q of a coil and its dependence on frequency, using a Q- meter.
5. Measurement of voltage, frequency, time period and phase angle using CRO.
6. Measurement of time period, frequency, average period using universal counter/ frequency counter.

5. Measurement of rise, fall and delay times using a CRO.
6. Measurement of distortion of a RF signal generator using distortion factor meter.
7. Measurement of R, L and C using a LCR bridge/ universal bridge.

**Open Ended Experiments:**

8. Using a Dual Trace Oscilloscope
9. Converting the range of a given measuring instrument (voltmeter, ammeter)

**Reference Books:**

A text book 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, Shimon P. Vingron, 2012, Springer.
Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
Electronic circuits: Handbook of design and applications, U.Tietze, Ch.Schenk, 2008, Springer
Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

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## PHY-SEC5 RENEWABLE ENERGY AND ENERGY HARVESTING

**Total Lectures : 30** **Credits: 2**

**Max. Marks : 50**

**Objective : The aim of this course is not just to impart theoretical knowledge to the students but to provide them with exposure and hands-on learning wherever possible**

**Note: The students in the class will be divided in to groups. There will be regular teaching of the theoretical aspects (8 hours) along with the Practical training of the students in various skill Development Subjects. Students shall submit a report of nearly 20 pages about the work done (giving details, highlighting innovation and future prospectus) by the end-semester. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.**

**Fossil fuels and Alternate Sources of energy:** Fossil fuels and nuclear energy, their limitation, 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, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity. (3 Lectures)

Solar energy: 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, and sun tracking systems.
(6 Lectures)

Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies. (3 Lectures)

Ocean Energy: Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices.
Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.
(2 Lectures)

Geothermal Energy: Geothermal Resources, Geothermal Technologies. (2 Lectures)

Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources. (2 Lectures) Piezoelectric Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power
(4 Lectures)

Electromagnetic Energy Harvesting: Linear generators, physics mathematical models, recent applications. (2 Lectures)

Carbon captured technologies, cell, batteries, power consumption (2 Lectures)

Environmental issues and Renewable sources of energy, sustainability. (1 Lecture)

## Demonstrations and Experiments

12. Demonstration of Training modules on Solar energy, wind energy, etc.
13. Conversion of vibration to voltage using piezoelectric materials
14. Conversion of thermal energy into voltage using thermoelectric modules.

**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 Assesment Handbook, 2009**

**J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA). http://en.wikipedia.org/wiki/Renewable_energy**

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# Generic Elective Papers (GE) (Minor-Physics) for Physical Sciences & Bio Medical Sciences Departments/Disciplines

## PHY-C-GE3 : WAVES AND OPTICS

### PHY-C-GE3 (T) : WAVES AND OPTICS

### THEORY

**Total Lectures : 60** **Credits: 4**

**Max. Marks : 100**

**Objective : The course covers Harmonic oscillations and coupled oscillations, wave motion in damped, driven media. It also covers the Interference, diffraction and polarisation of light and their applications.**

**Superposition of Two Collinear Harmonic oscillations: Linearity & Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats).** **(4 Lectures)**

**Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.** **(2 Lectures)**

**Waves Motion- General: Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity.** **(7 Lectures)**

**Fluids: Surface Tension: Synclastic and anticlastic surface - Excess of pressure - Application to spherical and cylindrical drops and bubbles - variation of surface tension with temperature - Jaegar's method. Viscosity - Rate flow of liquid in a capillary tube - Poiseuille's formula - Determination of coefficient of viscosity of a liquid - Variations of viscosity of liquid with temperature- lubrication.** **(6 Lectures)**

**Sound: Simple harmonic motion - forced vibrations and resonance - Fourier's Theorem - Application to saw tooth wave and square wave - Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation - Absorption coefficient - Sabine's formula - measurement of reverberation time - Acoustic aspects of halls and auditoria.** **(6 Lectures)**

**Wave Optics: Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle.** **(3 Lectures)**

**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.**

**(10 Lectures)**

**Michelson's Interferometer: Idea of form of fringes (no theory needed), Determination of wavelength, Wavelength difference, Refractive index, and Visibility of fringes.**

**(3 Lectures)**

**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.**

**(14 Lectures)**

**Polarization: Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical** **(5 Lectures)**

**Reference Books:**

**Fundamentals of Optics, F.A Jenkins and H.E White, 1976, McGraw-**
**Hill 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. 13/e, 1986. Addison-Wesley**

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## PHY-C-GE3 (P) : WAVES AND OPTICS

## PRACTICAL

**Total Lectures : 60** **Credits: 2**

**Max. Marks : 50**

**Objective : The aim of the laboratory exercises is to train the students in handling the equipments, verifying some laws they study in theory and making them confident to perform precise measurements.**

**Note: The experiments listed in the Practical Part of the Generic Elective Papers, i.e., PHY-GE5P (B) : Waves and Optics, PHY-GE6P (B):Mathematical Physics II, PHY-GE7P (B): Digital, Analog Circuits and Instrumentation, PHY-GE8P (B): Thermal Physics and Statistical Mechanics, are to be clubbed together and will be performed by the students during the Semesters III and IV. Basic experiments of these Generic Elective papers will be covered in Semester III and the rest will be done in Semester IV. 8 experiments are to be performed in each Semester without repetition. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.**

8. **To investigate the motion of coupled oscillators**
9. **To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify $\lambda^2$ – T Law.**

16. To study Lissajous Figures
17. Familiarization with Schuster`s focussing; determination of angle of prism.
18. To determine the Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
19. To determine the Refractive Index of the Material of a Prism using Sodium Light.
20. To determine Dispersive Power of the Material of a Prism using Mercury Light
21. Determination of refractive index of prism for different wave-lengths using Spectrometer and deterrmine the value of Cauchy Constants.
22. To determine the Resolving Power of a Prism.
23. To determine wavelength of sodium light using Fresnel Biprism.
24. To determine wavelength of sodium light using Newton's Rings.
25. To determine the wavelength of Laser light using Diffraction of Single Slit.
26. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating
27. To determine the Resolving Power of a Plane Diffraction Grating.
28. To measure the intensity using photosensor and laser in diffraction patterns of single and double slits.
29. Determination of focal length of convex mirror by beam compass method.
30. Determination of magnifying power of a telescope by slit method.
31. Determination of resolving power of a telescope.
32. To determine the wave-length of laser light using a plane diffraction grating.
33. Determination of wave-length of sodium light by Newton's rings method.
34. Determination of specific rotation of sugar using a Polarimeter.
35. Determination of frequency of A.C. mains by using electrical vibrator.
36. Determination of velocity of ultrasonic waves in a given liquid

**Reference Books:**


7. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
8. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
9. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

## PHY-C-GE4 : DIGITAL, ANALOG CIRCUITS AND INSTRUMENTATION

### PHY-C-GE4 (T) : DIGITAL, ANALOG CIRCUITS AND INSTRUMENTATION THEORY

**Total Lectures : 60** **Credits: 4**

**Max. Marks : 100**

**Objective :** The course covers binary arithmetic, Logic gates, sequential and combinational circuits, semiconductor physics and devices, diodes and applications, bipolar junction transistors, amplifiers, Operation amplifiers and applications, CRO and Power supply.

**Digital Circuits**

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion, AND, OR and NOT Gates (Realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates.

(4 Lectures)

De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Minterms and Maxterms. Conversion of a Truth Table into an Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

(5 Lectures)

Binary Addition. Binary Subtraction using 2's Complement Method). Half Adders and Full Adders and Subtractors, 4-bit binary Adder-Subtractor. (4 Lectures)

**Semiconductor Devices and Amplifiers:**

Semiconductor Diodes: P and N type semiconductors. Barrier Formation in PN Junction Diode. Qualitative Idea of Current Flow Mechanism in Forward and Reverse Biased Diode. PN junction and its characteristics. Static and Dynamic Resistance. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell. (5 Lectures)

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Active, Cutoff & Saturation regions Current gains α and β. Relations between α and 7. Load Line analysis of Transistors. DC Load line & Q-point. Voltage Divider Bias Circuit for CE Amplifier. h-parameter Equivalent Circuit. Analysis of single-stage CE amplifier using hybrid Model. Input & output Impedance. Current, Voltage and Power gains. Class A, B & C Amplifiers.

(12 Lectures)

**Operational Amplifiers (Black Box approach):**

Characteristics of an Ideal and Practical Op-Amp (IC 741), Open-loop and closed-loop Gain. CMRR, concept of Virtual ground. Applications of Op-Amps: (1) Inverting and non-inverting Amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Zero crossing detector. (13 Lectures)

**Sinusoidal Oscillators:** Barkhausen's Criterion for Self-sustained Oscillations. Determination of Frequency of RC Oscillator

(5 Lectures)

**Instrumentations:** Introduction to CRO: Block Diagram of CRO. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference.

(3 Lectures)

**Power Supply:** Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers Calculation of Ripple Factor and Rectification Efficiency, Basic idea about capacitor filter, Zener Diode and Voltage Regulation. (6 Lectures)

**Timer IC:** IC 555 Pin diagram and its application as Astable and Monostable Multivibrator. (3 Lectures)

**Reference Books:**

Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.

Electronic devices & circuits, S. Salivahanan & N.S. Kumar, 2012, Tata Mc-Graw Hill

Microelectronic Circuits, M.H. Rashid, 2nd Edn., 2011, Cengage Learning.

Modern Electronic Instrumentation and Measurement Tech., Helfrick and Cooper, 1990, PHI Learning

Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw Hill

Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.

Fundamentals of Digital Circuits, A. Anand Kumar, 2nd Edition, 2009, PHI Learning Pvt. Ltd.

OP-AMP & Linear Digital Circuits, R.A. Gayakwad, 2000, PHI Learning Pvt. Ltd.

## PHY-C-GE4 (P) : DIGITAL, ANALOG CIRCUITS AND INSTRUMENTATION PRACTICAL

**Total Lectures : 60** **Credits: 2**

**Max. Marks : 50**

**Objective : The experiments included in this laboratory course are aimed at training the students to the digital and analogue electronics and develop confidence to use later the sophisticated instruments in their respective fields.**

**Note: The experiments listed in the Practical Part of the Generic Elective Papers, i.e., PHY-GE5P (B): Waves and Optics, PHY-GE6P (B): Mathematical Physics II, PHY-GE7P (B): Digital, Analog Circuits and Instrumentation, PHY-GE8P (B): Thermal Physics and Statistical Mechanics, are to be clubbed together and will be performed by the students during the Semesters III and IV. Basic experiments of these Generic Elective papers will be covered in Semester III and the rest will be done in Semester IV. 8 experiments are to be performed in each Semester without repetition. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.**

2. To measure (a) Voltage, and (b) Frequency of a periodic waveform using CRO
3. To verify and design AND, OR, NOT and XOR gates using NAND gates.
4. To minimize a given logic circuit.
5. Half adder, Full adder and 4-bit Binary Adder.
6. Adder-Subtractor using Full Adder I.C.
7. To design an astable multivibrator of given specifications using 555 Timer.
8. To design a monostable multivibrator of given specifications using 555 Timer.
9. To study IV characteristics of PN diode, Zener and Light emitting diode
10. To study the characteristics of a Transistor in CE configuration.
11. To design a CE amplifier of given gain (mid-gain) using voltage divider bias.
12. To design an inverting amplifier of given gain using Op-amp 741 and study its frequency response.
13. To design a non-inverting amplifier of given gain using Op-amp 741 and study its Frequency Response.
14. To study Differential Amplifier of given I/O specification using Op-amp.
15. To investigate a differentiator made using op-amp.
16. To design a Wien Bridge Oscillator using an op-amp.

2 Study of Solar-Cell characterstics

3 Study of C.R.O. as display and measuring device, Study of Sine-wave, square wave signals (half wave and full wave rectification)

4 Study of power supply, ripple factor - effect of filters.

5 Study of vacuum triode characteristics.

**Reference Books:**

Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.

Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.

OP-Amps & Linear Integrated Circuit, R.A. Gayakwad, 4th Edn, 2000, Prentice Hall.

Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.

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**Semester V**

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## PHYSICS-C11: QUANTUM MECHANICS AND APPLICATIONS

## PHYSICS-C11 (T): QUANTUM MECHANICS AND APPLICATIONS

### THEORY

**Total Lectures: 60** **Credits: 4**

**Max. Marks : 100**

**Objective : The course content covers basis of quantum mechanics, Time dependent and time independent Schrodinger equations and their solutions with different potentials, applications of quantum mechanics for hydrogen-like and many electron atoms and atoms in electric and magnetic fields.**

**Time dependent Schrodinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle.** **(6 Lectures)**

**Time independent Schrodinger equation-Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.** **(10 Lectures)**

**General discussion of bound states in an arbitrary potential- continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle.**

**(12 Lectures)**

**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 & quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground & first excited states; Orbital angular momentum quantum numbers l and m; s, p, d,.. shells. (10 Lectures) Atoms in Electric & 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. (8 Lectures) Atoms in External Magnetic Fields: Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only). (4 Lectures)**

**Many electron atoms: Pauli's Exclusion Principle. Symmetric & 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.). (10 Lectures)**

**Reference Books:**


2 **A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill**

3 **Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.**

**4 Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill. 5**

**Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.**

6 **Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.**

7 **Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer**

8 **Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press**

5. **Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.**
6. **Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education**
7. **Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer**

# PHY-C11 (P): ELEMENTS OF MODERN PHYSICS
## PRACTICALS

**Total Lectures : 60** **Credits: 2**

**Max. Marks : 50**

**Objective : The computer based experiments involve use of C/C++/Scilab for solving the following problems based on Quantum Mechanics.The laboratory experiments forming basis of quantum mechanics Zeeman effect, Electron spin resonance, tunneling effect and quantum efficiency of detectors.**

**Note: The experiments listed in the Practical Part of the Core Papers are to be clubbed together and will be performed by the students during the Semesters V and VI. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.**

**Use C/C$^{++}$/Scilab for solving the following problems based on Quantum Mechanics like**

8. **Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:**

$$\frac{\phantom{x}}{\phantom{x}^2} =,= \frac{\phantom{x}^2}{\hbar^2} - \qquad \hbar =- \qquad \frac{\phantom{x}^2}{\phantom{x}}$$

**Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is ≈ - 13.6 eV. Take e = 3.795 (eVÅ)$^{1/2}$, ħc = 1973 (eVÅ) and m = 0.511x10$^6$ eV/c$^2$.**

2. **Solve the s-wave radial Schrodinger equation for an atom:**

$$\frac{\phantom{x}^2}{\phantom{x}^2} =,= \frac{\phantom{x}^2}{\hbar^2} -$$

**where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential**

**Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 (eVÅ)$^{1/2}$, m = 0.511x10$^6$ eV/c$^2$, and a = 3**

Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

3. Solve the s-wave radial Schrodinger equation for a particle of mass m:

$$\frac{{}^2}{{}^2} =,= \qquad \frac{2}{\hbar^2} -$$

For the anharmonic oscillator potential

$$= \frac{1}{2} {}^2 + \frac{1}{3} {}^2$$

for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose m = 940 MeV/$c^2$, k = 100 MeV fm-2, b = 0, 10, 30 MeV fm-3In these units, cħ = 197.3 MeV fm. The ground state energy I expected to lie between 90 and 110 MeV for all three cases.

4. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule:

$$\frac{{}^2}{{}^2} =, \qquad = \frac{2}{\hbar_2} -$$

Where is the reduced mass of the two-atom system for the Morse potential

$$' = \qquad \frac{}{}$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits.

Also plot the corresponding wave function.

Take: m = 940 x $10^6$eV/$C^2$, D = 0.755501 eV, α = 1.44, $r_o$ = 0.131349 A

Laboratory based experiments:

12. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency
13. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
14. To show the tunneling effect in tunnel diode using I-V characteristics.
15. Quantum efficiency of CCDs

8. Study of excitations of a given atom by Franck Hertz set up.
9. To determine charge to mass ratio (e/m) of an electron by Thomson method.
10. Determination of dissociation limit of iodine molecule by constant deviation spectrograph
11. Study of Arc emission spectrum of given samples (Fe and Cu).

**Reference Books:**


16. Schaum's outline of Programming with C++. J.Hubbard, 2000,McGraw - Hill Publication
17. Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal., 3rd Edn., 2007, Cambridge University Press.
18. An introduction to computational Physics, T.Pang, 2nd Edn.,2006, Cambridge Univ. Press
19. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández.2014 Springer.
20. Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
21. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
22. Scilab Image Processing: L.M.Surhone.2010 Betascript Publishing ISBN:978-6133459274


## PHYSICS-C12: SOLID STATE PHYSICS

## PHYSICS-C12 (T): SOLID STATE PHYSICS

### THEORY

**Total Lectures: 60** **Credits: 4**

**Max. Marks : 100**

**Objective :** The course content covers understanding of crystal structure, band theory of solid, lattice dynamics, magnetic and dielectric properties of matter, ferroelectric materials, and superconductivity phenomenon.

**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. (12 Lectures)

**Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear Monoatomic 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 (10 Lectures) 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. (8 Lectures)**

**Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes. (8 Lectures)**

**Ferroelectric Properties of Materials: Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop. (6 lectures)** **Elementary band theory: Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (04 probe method) & Hall coefficient. (10 Lectures) 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) (6 Lectures)**

**Reference Books:**

7. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
8. Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India
9. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
10. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
11. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
12. Solid State Physics, Rita John, 2014, McGraw Hill
13. Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
14. Solid State Physics, M.A. Wahab, 2011, Narosa Publications

## PHY-C12 (P): SOLID STATE PHYSICS
## PRACTICALS

**Total Lectures : 60 Credits: 2**

**Max. Marks : 50**

**Objective : The computer based experiments involve use of C/C++/Scilab for solving the following problems based on Quantum Mechanics.The laboratory experiments forming basis of quantum mechanics Zeeman effect, Electron spin resonance, tunneling effect and quantum efficiency of detectors.**

**Note: The experiments listed in the Practical Part of the Core Papers are to be clubbed together and will be performed by the students during the Semesters V and VI. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.**

1. **To measure magnetic volume susceptibility of liquid - $FeCl_2$/$MnSo_4$ solution by Quincke's 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 determine the complex dielectric constant and plasma frequency of metal usingSurface Plasmon resonance (SPR)**
6. **To determine the refractive index of a dielectric layer using SPR**
7. **To study the PE Hysteresis loop of a Ferroelectric Crystal.**
8. **To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.**
9. **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.**
10. **To measure dielectric constant of a non-polar liquid and its applications.**
11. **To determine the Hall coefficient and mobility of given semiconductors.**
12. **To find conductivity of given semiconductor crystal using four probe method.**

**Reference Books**


1. **Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.**
2. **Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.**
3. **A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal**
4. **Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.**

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**Semester VI**

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## PHYSICS-C13: ELECTROMAGNETIC THEORY

## PHYSICS-C13 (T): ELECTROMAGNETIC THEORY

### THEORY

**Total Lectures: 60** **Credits: 4**

**Max. Marks : 100**

**Objective : The students are exposed to Maxwell equations and their applications, EM wave propagation in unbounded and bounded media,wave guides and optical fibres, polarization properties of em waves.**

**Maxwell Equations: Review of 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. (12 Lectures)**

**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. (10 Lectures)**

**EM Wave in Bounded Media: Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence) (10 Lectures)**

**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 & extraordinary refractive indices. Production & 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**

**(12 Lectures)**

**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.** **(5 Lectures)**

**Wave Guides: Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission. (8 Lectures) Optical Fibres:- Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only). (3 Lectures)**

**Reference Books:**

1. **Introduction to Electrodynamics, D.J. Griffiths, 3$^{rd}$ Ed., 1998, Benjamin Cummings.**
2. **Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.**
3. **Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning**
4. **Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill**
5. **Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning**
6. **Engineering Electromagnetic, Willian H. Hayt, 8$^{th}$ Edition, 2012, McGraw Hill.**
7. **Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer**

**Additional Books for Reference**

1. **Electromagnetic Fields & Waves, P.Lorrain & D.Corson, 1970, W.H.Freeman & Co.**
2. **Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.**
3. **Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004, Cambridge University Press**

## PHY-C13 (P): ELECTROMAGNETIC THEORY
## PRACTICALS

**Total Lectures : 60** **Credits: 2**

**Max. Marks : 50**

**Objective : The laboratory experiments based on refraction, polarization, diffraction properties of e.m. waves.**

**Note: The experiments listed in the Practical Part of the Core Papers are to be clubbed together and will be performed by the students during the Semesters V and VI. General evaluation procedure has been defined under the heading "Evaluation" in the beginning of the syllabus.**

**To verify the law of Malus for plane polarized light.**

1. **To determine the specific rotation of sugar solution using Polarimeter.**
2. **To analyze elliptically polarized Light by using a Babinet's compensator.**
3. **To study dependence of radiation on angle for a simple Dipole antenna.**
4. **To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.**
5. **To study the reflection, refraction of microwaves**
6. **To study Polarization and double slit interference in microwaves.**
7. **To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.**
8. **To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.**
9. **To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.**
10. **To verify the Stefan`s law of radiation and to determine Stefan's constant.**
11. **To determine the Boltzmann constant using V-I characteristics of PN junction diode.**
12. **To study transmission line modeled as LC ladder and find out its propagation constant.**
13. **To measure the Numerical Aperture of Optical Fiber and study Propagation Loss and Bending Losses.**
14. **Refractive index of air using Jamin's Interferometer.**
15. **To study the Michelson interferometer and its application.**
16. **To study the intensity profile of the diffraction pattern of single slit and verify the uncertainty principle by using LASER.**

**Reference Books**

1. **Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.**
2. **Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers**
3. **A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal**
4. **Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer**

## PHYSICS-C14: STATISTICAL MECHANICS

## PHYSICS-C14 (T): STATISTICAL MECHANICS

## THEORY

**Total Lectures: 60** **Credits: 4**

**Max. Marks : 100**

**Objective : The students are exposed to Classical statistics, Classical and quantum theory of radiation, Bose-Einstein and Fermi-Dirac statistics and their applications.**

**Classical Statistics: Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, 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.**

**(18 Lectures)**

**Classical Theory of Radiation: Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Saha's Ionization Formula. Rayleigh-Jean's Law. Ultraviolet Catastrophe. (9 Lectures) Quantum Theory of Radiation: Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law.** **(5 Lectures)**

**Bose-Einstein Statistics:** B-E 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.

(13 Lectures)

**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. (15 Lectures)

**Reference Books:**


1. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
2. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
3. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
5. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
6. An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press


## PHY-C14 (P): STATISTICAL MECHANICS
## PRACTICALS

**Total Lectures : 60 Credits: 2**

**Max. Marks : 50**

**Objective :** The computer based numerical simulations involving use of C/C++/Scilab for handling the problems based on Statistical Mechanics.

Use C/C++/Scilab/other numerical simulations for solving the problems based on Statistical Mechanics like

1. Computational analysis of the behavior of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:
   a) Study of local number density in the equilibrium state (i) average; (ii) fluctuations
   b) Study of transient behavior of the system (approach to equilibrium)

c) Relationship of large N and the arrow of time

d) Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution

e) Computation and study of mean molecular speed and its dependence on particle mass

f) Computation of fraction of molecules in an ideal gas having speed near the most probable speed

2. Computation of the partition function Z(β) for examples of systems with a finite number of single particle levels (e.g., 2 level, 3 level, etc.) and a finite number of non-interacting particles N under Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics:

a) Study of how Z(β), average energy <E>, energy fluctuation E, specific heat at constant volume $C_v$, depend upon the temperature, total number of particles N and the spectrum of single particle states.

b) Ratios of occupation numbers of various states for the systems considered above

c) Computation of physical quantities at large and small temperature T and comparison of various statistics at large and small temperature T.

3 Plot Planck's law for Black Body radiation and compare it with Raleigh-Jeans Law at high temperature and low temperature.

4 Plot Specific Heat of Solids (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature and low temperature and compare them for these two cases.

5 Plot the following functions with energy at different temperatures

a) Maxwell-Boltzmann distribution

b) Fermi-Dirac distribution

c) Bose-Einstein distribution

**Reference Books:**


1 Elementary Numerical Analysis, K.E.Atkinson, 3rd Edn . 2007 , Wiley India Edition

2 Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University

3 Introduction to Modern Statistical Mechanics, D. Chandler, Oxford University Press, 1987

4 Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.

5 **Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer**

6 **Statistical and Thermal Physics with computer applications, Harvey Gould and Jan Tobochnik, Princeton University Press, 2010.**

7 **Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896**

8 **Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444**

9 **Scilab Image Processing: L.M.Surhone. 2010, Betascript Pub., ISBN: 9786133459274**

# Discipline Specific Elective Courses (any four) (Credit: 06 each) PHY-DSE1 to PHY-DSE6

## PHY-DSE1: NUCLEAR PHYSICS

**Total Lectures: 75** **Credits: 6 (Credits: Theory-05, Tutorials-01)**

**Max. Marks : 150**

**Objective : The course contents covers general properties of nuclei, nuclear models, radioactive decays, Nuclear reactions, fission and fusion processes and applications,ineraction of gamma ray, charged particles and neutrons radiation with matter and respective detectors.**

**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, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states.**

**(10 Lectures)**

**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 fermion 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, Meson theory of nuclear forces.** **(12 Lectures)**

**Radioactivity decay: (a) Alpha decay: basics of α-decay processes, radioactive series, tunnel theory of α emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) β-decay: $\beta^-$, $\beta^+$, EC decays, beta energy spectrum, end point energy, Gamma decay: Gamma rays emission & kinematics, internal conversion.**

**(12 Lectures)**

**Nuclear Reactions: Types of Reactions, Coulomb scattering (Rutherford scattering), Coulomb barrier, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction.** **(10 Lectures)**

**Fission and Fusion:** Nuclear reactors, Breeder reactors, Nuclear fusion in stars, formation of heavier elements, Nuclear reactor accidents – Chernobyl and Fukushima, Nuclear weapons, Fusion reactors, Inetrantional thermonuclear experimental reactor (ITER). (9 Lectures)

**Interaction of radiation and charged particles with matter :** Interaction of gamma rays with matter - photoelectric effect, Compton scattering, pair production, Energy loss of electrons and positrons, Positron annihilation in condensed media, Stopping power and range of heavier charged particles, derivation of Bethe-Bloch formula, neutron interaction with matter. (12 Lectures)

**Detector for Nuclear Radiations:** Gas-filled detectors: ionization chamber, proportional counter and GM Counter. Basic principle of Organic and Inorganic scintillation detectors for gamma and electron radiation, photo-multiplier tube, Semiconductor detectors, Solid state nuclear track detectors, Neutron detector, Cherenkov detector, radiation monitoring devices.

(10 Lectures)

**Reference Books:**


1 Introductory Nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).

2 Concepts of Nuclear Physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).

3. Concepts of Modern Physics by Arthur Beiser, Shobit Mahajan and S. Rai Choudhury (Tata Mcgraw Hill, 2006).

4. Modern Physics by J. Bernstein, Paul M.. Fishbane, S. G. Gasiorowicz (Pearson, 2000).

5. Introduction to the physics of Nuclei & Particles, R.A. Dunlap. (Thomson Asia, 2004).

6. Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP-Institute of Physics Publishing, 2004).

7. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).

8. Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).

9. Theoretical Nuclear Physics, J.M. Blatt & V.F.Weisskopf (Dover Pub.Inc., 1991).

## PHY-DSE2: EXPERIMENTAL TECHNIQUES

## PHY- DSE2 (T): EXPERIMENTAL TECHNIQUES

### THEORY

**Total Lectures: 60** **Credits: 4**

**Max. Marks : 100**

**Objective : The course content covers basics of experimental measurements, working principle of transducers and their applications, industrial instrumentation, and vacuum techniques.**

**Measurements: Accuracy and precision. Significant figures. Error and uncertainty analysis. Types of errors: Gross error, systematic error, random error. Statistical analysis of data (Arithmetic mean, deviation from mean, average deviation, standard deviation, chi-square) and curve fitting. Guassian distribution. (7 Lectures) Signals and Systems: Periodic and aperiodic signals. Impulse response, transfer function and frequency response of first and second order systems. Fluctuations and Noise in measurement system. S/N ratio and Noise figure. Noise in frequency domain. Sources of Noise: Inherent fluctuations, Thermal noise, Shot noise, 1/f noise (7 Lectures)**

**Shielding and Grounding: Methods of safety grounding. Energy coupling. Grounding. Shielding: Electrostatic shielding. Electromagnetic Interference. (4 Lectures)**

**Transducers & industrial instrumentation (working principle, efficiency, applications): Static and dynamic characteristics of measurement Systems. Generalized performance of systems, Zero order first order, second order and higher order systems. Electrical, Thermal and Mechanical systems. Calibration. Transducers and sensors. Characteristics of Transducers. Transducers as electrical element and their signal conditioning. Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning. Linear Position transducer: Strain gauge, Piezoelectric. Inductance change transducer: Linear variable differential transformer (LVDT), Capacitance change transducers. Radiation Sensors: Principle of Gas filled detector, ionization chamber, scintillation detector. (21 Lectures) Digital Multimeter: Comparison of analog and digital instruments. Block diagram of digital multimeter, principle of measurement of I, V, C. Accuracy and resolution of measurement. (5 Lectures)**

**Impedance Bridges and Q-meter: Block diagram and working principles of RLC bridge. Q-meter and its working operation. Digital LCR bridge. (4 Lectures)**

**Vacuum Systems: Characteristics of vacuum: Gas law, Mean free path. Application of vacuum. Vacuum system- Chamber, Mechanical pumps, Diffusion pump & Turbo Modular pump, Pumping speed, Pressure gauges (Pirani, Penning, ionization).** **(12 Lectures)**

**Reference Books:**


1 **Measurement, Instrumentation and Experiment Design in Physics and Engineering, M. Sayer and A. Mansingh, PHI Learning Pvt. Ltd.**

2 **Experimental Methods for Engineers, J.P. Holman, McGraw Hill**

3 **Introduction to Measurements and Instrumentation, A.K. Ghosh, 3rd Edition, PHI Learning Pvt. Ltd.**

4 **Transducers and Instrumentation, D.V.S. Murty, 2nd Edition, PHI Learning Pvt. Ltd.**

5 **Instrumentation Devices and Systems, C.S. Rangan, G.R. Sarma, V.S.V. Mani, Tata McGraw Hill**

6 **Principles of Electronic Instrumentation, D. Patranabis, PHI Learning Pvt. Ltd.**

7 **Electronic circuits: Handbook of design & applications, U.Tietze, Ch.Schenk, Springer**


## PHY-DSE2 (P): EXPERIMENTAL TECHNIQUES PRACTICALS

**Total Lectures : 60 Credits: 2**

**Max. Marks : 50**

1 **Determine output characteristics of a LVDT & measure displacement using LVDT**

**2 Measurement of Strain using Strain Gauge.**

**3 Measurement of level using capacitive transducer.**

**4 To study the characteristics of a Thermostat and determine its parameters.**

**5 Study of distance measurement using ultrasonic transducer.**

**6 Calibrate Semiconductor type temperature sensor (AD590, LM35, or LM75)**

**7 To measure the change in temperature of ambient using Resistance Temperature Device (RTD).**

**8 Create vacuum in a small chamber using a mechanical (rotary) pump and measure the chamber pressure using a pressure gauge.**

**9 Comparison of pickup of noise in cables of different types (co-axial, single shielded, double shielded, without shielding) of 2m length, understanding of importance of grounding using function generator of mV level & an oscilloscope.**

10 **To design and study the Sample and Hold Circuit.**

11 **Design and analyze the Clippers and Clampers circuits using junction diode**

12 **To plot the frequency response of a microphone.**

13 **To measure Q of a coil and influence of frequency, using a Q-meter.**

14 **Measurement of thermal relaxation time constant of a serial light bulb.**

15 **To study the series and parallel L.C.R. circuit and find its Q factor for different resistances.**

16 **To study the characteristics of given voltage doubler and tripler.**

17 **To study the clipping and clamping circuits.**

18 **To study the frequency response of given RC coupled transistor amplifier and determine its band width.**

19 **To determine the distributed capacity of given inductance coil.**

20 **To determine the given capacitance using flashing and quenching of a neon bulb.**

21 **To determine the operating plateau and dead time of a given G.M. Counter.**

22 **To study the high energy interactions in nuclear emulsion – Energy of star.**

23 **To study the characteristics of silicon and GaAs solar cells.**

24 **To study the characteristics of LED and photodiode.**

25 **To study the variation of the magneto-resistance of a sample with the applied magnetic field.**

26 **To design astable multivibrator using transistors.**

27 **To study the amplitude modulation.**

**Reference Books:**

1 **Electronic circuits: Handbook of design and applications, U. Tietze and C. Schenk, 2008, Springer**

2 **Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1990, Mc-Graw Hill**

**3 Measurement, Instrumentation and Experiment Design in Physics & Engineering, M. Sayer and A. Mansingh, 2005, PHI Learning.**

## PHY-DSE3: ATOMIC AND MOLECULAR PHYSICS

**Total Lectures: 75** **Credits: 6**

**Max. Marks : 150**

**Objective : The course contents covers the hydrogen and alkali spectra, coupling schemes, atoms in magnetic fields, Infrared and Raman spectroscopy, and electron spectra, line broadening mechanisms and Lasers.**

### UNIT I

**Hydrogen and Alkai Spectra: Series in hydrogen, nuclear mass effect, elliptical orbits, Sommerfeld model, spin-orbit coupling, relativistic correction and Lamb shift (qualitative). Alkali Spectra and intensity ratios in doublets**

**Complex Spectra: LS-Coupling scheme, normal triplets, basic assumptions of the theory, identification of terms, selection rules, jj- coupling, Lande's interval rule, Selection rules, intensity ratios, regularities in complex spectra. Normal and anomalous Zeeman and Paschen Back effects, intensity rules.** **(15 Lectures)**

### UNIT II

**Infrared and Raman Spectra: Rigid rotator, energy levels, spectrum, intensity of rotational lines, Harmonic oscillator: energy levels, eigenfunctions, spectrum, Raman effect, Quantum theory of Raman effect, Rotational and Vibrational Raman spectrum. Anharmonic oscillator: energy levels, Infrared and Raman Spectrum, Vibrational frequency and force constants, Dissociation of molecules. Non-rigid rotator including symmetric top: energy levels, spectrum, Vibrating-rotator energy levels, Infrared and Raman spectrum, Symmetry properties of rotational levels, influence of nuclear spin, isotope effect on rotational spectra.**

**Electronic Spectra: Classification of electronic states: Orbital angular momentum, Electronic energy and potential curves, resolution of total energy, Vibrational Structure of Electronic transitions. Vibrational analysis, Rotational Structure of Electronic bands: General relations, branches of a band, band-head formation, Intensity distribution in a vibrational band system. Franck-Condon Principle and its wave mechanical formulation.** **(40 Lectures)**

## UNIT III

**Lasers : Temporal and spatial coherence, shape and width of spectral lines, line broadening mechanism, natural, collision and Doppler broadening.**

**II. Laser Pumping and Resonators: Resonators, modes of a resonator, number of modes per unit volume, quality factor, threshold condition.**

**III. Dynamics of the Laser Processes: Rate equations for two, three and four level systems, production of a giant pulse – Q switching, mode-locking.**

**IV. Types of Lasers: He-Ne gas laser, Nitrogen Laser, $CO_2$ laser, Ruby laser, Semiconductor lasers, dye lasers.**

**V. Applications: Holography, non-linear optics: harmonic generation, second harmonic generation, phase matching and optical mixing.** **(20 Lectures)**

**TUTORIALS: Problems pertaining to the topics covered in the course.**

**Recommended Books:**

1. **Atomic Spectra: H. Kuhn (Longman Green) 1969.**
2. **Molecular Spectra and Molecular Structure I: G. Herzberg (Van-Nostrand Rein-hold), 1950.**
3. **Atomic Spectra: H.E. White (McGraw Hill) 1934.**
4. **Fundamentals of Molecular spectroscopy: Banwell and McCash (Tata McGraw Hill), 1994.**
5. **Molecular Spectroscopy: S. Chandra (Narosa), 2009.**
6. **Atomic, Molecular and Photons, Wolfgang Damtrodes (Springer), 2010.**
7. **Lasers and Non-linear Optics: B.B. Laud. (Wiley Eastern), 1991.**
8. **Principles of Lasers: O. Svelto (Plenum Press), 4th edition, 1998.**
9. **An Introduction to Lasers and their applications: D.C.O'Shea, W. Russell and W.T. Rhodes (Addition –Wesley), 1977.**
10. **Laser Theory and Applications : Thyagarajan and A. Ghatak (Plenum) 1981 (reprint : MacMillan)**

## PHY-DSE4: PARTICLE PHYSICS

**Total Lectures: 75** **Credits: 6 (Theory-05, Tutorials-01)**

**Max. Marks : 150**

**Objective : The course contents covers the elementary particles, cosmic rays, particle properties and their reactions, evolution of universe, Partcle accelerators, colliding beams, and detectors for high energy physics.**

**Elementary Particles : Historical introduction, fermions and bosons, particles and antiparticles, Classification of elementary particles and their interactions - electromagnetic, weak, strong and gravitational interactions. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, Discovery of quarks, concept of quark flavor, color quantum number, Interactions among quarks, Yukawa theory, Field bosons, Standard model and beyond, Higgs boson. (18 Lectures) Cosmic Connection: Cosmic rays, sources of cosmic rays and production of secondary cosmic rays in atmosphere, Van allen radiation belt, Carbon-14 and other isotopic datings, soft and hard cosmic rays, cosmic ray experiments: discovery of particles, Brief about ground based experiments – GRAPES. (12 Lectures)**

**Particle Properties and their reactions: Properties and life time of muon, pions: Determination of mass, spin and parity. Lifetime of neutral pion and isotopic spin. Strange particles: V particles, charged K-mesons, mass and life time for charged K-mesons. Observations of different strange particles , strange particle production and decay.Strangeness and Hypercharge. (15 Lectures)**

**VIII. Particles and evolution of Universe: Big bang expansion: size, time and temperature, formation of particles, relic radiation. Source of energy in Stars: fusion reactions, solar and atmospheric neutrinos, Black holes, Neutron stars, Concept of dark matter and dark energy. (12 Lectures)**

**Particle Accelerators: Acceleartors, Ion sources, Introduction to beam optics, beamline components – magnets and vacuum systems.**

**Linear accelerator, Cockroft accelerator, Van-de Graaff generator, Tandem accelerator, Cyclotron, Electron synchrotron, Accelerator facilities in India. Introduction to colliding beam machines CERN LHC facility. (10 Lectures)**

**Detectors : Nuclear emulsions, Bubble chamber, Cloud chamber, Position-sensitive gas-filled and scintillator detectors, electromagnetic calorimeter and hadron calorimeter.**

**(8 Lectures)**

**Reference Books:**


1. **Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press**
2. **Introduction to Elementary Particles, D. Griffith, John Wiley & Sons**
3. **Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi**
4. **Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).**
5. **Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).**
6. **Concepts of Modern Physics by Arthur Beiser, Shobit Mahajan and S. Rai Choudhury (Tata Mcgraw Hill, 2006).**
7. **Modern Physics by J. Bernstein, Paul M.. Fishbane, S. G. Gasiorowicz (Pearson, 2000).**


## PHY-DSE5: PHYSICS OF RESONANCE TECHNIQUES

**Total Lectures: 75** **Credits: 6**

**Max. Marks : 150**

**Objective : The students are exposed to physics of hyperfine inert=actions, Mossbauer spectroscopy, electron spin resonance, Nuclear magnetic resonance and other resonance techniques.**

**I. Hyperfine Interactions: Electrostatic hyperfine interaction, Monopole and quadrupole interactions.**

**Magnetic hyperfine interaction, Origin of magnetic hyperfine flux density, Combined electric and magnetic hyperfine interactions.**

**II. Mossbauer Spectroscopy: Spectral line-shape of -rays, Recoilless emission of -rays, Resonance fluorescence and nuclear gamma resonance, Mossbauer spectrum – Isomer shift, Quadrupole splitting, Magnetic hyperfine structure, Combined electric and magnetic hyperfine splitting, line intensity, line width.**

**Mossbauer spectrometer, Applications.**

**III. Electron Spin Resonance: Basic resonance condition, absorption of electromagnetic energy and relaxation, ESR spectrometer, Spin Hamiltonian, Hyperfine structure, The ESR spectrum – line position, line intensity, line width. Applications.**

**IV. Nuclear Magnetic Resonance: Quantum mechanical description of NMR; The Bloch equation and its solutions – free precession; steady state in weak r.f. field, in-phase and out-of-phase susceptibilities, power absorption; Saturation effects at high radio-frequency power; intense r.f. pulses. Fourier Transform NMR. The NMR spectrum – Chemical shift, spin-spin coupling. NMR spectrometer. Applications.**

**V. Other Resonance Phenomena: Nuclear quadrupole resonance and its applications, Ferromagnetic resonance – shape effects and applications.**

**TUTORIALS: Relevant problems on the topics covered in the course.**

**Recommended Books:**


1. **Spectroscopy (Vol. I) eds.: B.P. Straughan and S. Walker (Chapman & Hall) 1976.**
2. **Hyperfine Interactions: A.J. Freeman and R.B. Frankel (Academic Press) 1967.**
3. **Chemical Applications of Mossbauer Spectroscopy: V.I. Goldanskii and R.H. Herber (Academic Press) 1968.**
4. **Principles of Magnetic Resonance: C.P. Slichter (Springer – Verlag) 1990.**
5. **Introduction to Solid State Physics: C. Kittel (John Wiley) 8th ed. 2005.**
6. **Molecular Structure and Spectroscopy: G. Aruldhas (Prentice Hall of India), 2007.**


## PHY-DSE6: DISSERTATION

**Total Lectures: 75** **Credits: 6**

**Max. Marks : 150**

**The aim of project work in B.Sc (H.S.) 5th semester is to expose the students to Advanced Physics Synthesis, Characterisation and Analytical / Data Analysis Techniques. It may include development of equipment in a research laboratory, or fabrication of a device. Project work based on participation in some ongoing research activity or analysis of data or review of some research papers is excluded. A student will work under the guidance of a faculty member from the department before the end of the 5th semester. Scientists and Engineers from other departments of the university and Institutes in and around Chandigarh can act as co-supervisors. A report of nearly 50 pages about the work done in the project (typed on both the sides of the paper and properly bound) will be submitted by a date to be announced by the UGAPMEC. Assessment of the work done under the project will be carried out by a committee on the basis of grasp of the problem assigned, effort put in the execution of the project, degree of interest shown in learning the methodology, report prepared, and viva-voce/seminar, etc as per guidelines prepared by the UGAPMEC.**