B.Sc. (Hons.) Physics (Specialization in Electronics) under the Framework of Honours School System

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2019-20
B.Sc. (Hons.) Physics (Specialization in Electronics) under the Framework of Honours School System
PANJAB UNIVERSITY, CHANDIGARH
OUTLINES OF TESTS, SYLLABI AND COURSES OF READING FOR
CHOICE BASED CREDIT SYSTEM
B.Sc. (HONOURS) IN PHYSICS (SPECIALIZATION IN ELECTRONICS)
UNDER THE FRAMEWORK OF HONOURS SCHOOL SYSTEM
(SEMESTER SYSTEM) EXAMINATION, 2019-2020

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

Laboratory Practicals:

Practical Lab. Course-1 (PHE-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 (PHE-CT3) Electricity and Magnetism 100 Marks (4 credits)
Core Course-4 (PHE-CT4) Waves and Optics 100 Marks (4 credits)

Laboratory Practicals:
Practical Lab. Course-2 (PHE-PL2) Mathematical Physics – I 100 Marks (4 credits)
Mechanics
Electricity and Magnetism
Waves and Optics

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. PHE-SEC1: Physics Enhancement Skills 50 Marks (2 credits)
2. PHE-SEC2: Computational Physics Skills 50 Marks (2 credits)
3. PHE-SEC3: Electrical Circuits and Network Skills 50 Marks (2 credits)
4. PHE-SEC4: Basic Instrumentation Skills 50 Marks (2 credits)
5. PHE-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:

(viii) Mathematics
(ix) Chemistry/BioChemistry
(x) Economics
(xi) Computer Science
(xii) Statistics
(xiii) Geology
(xiv) 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)
B.Sc. (Hons.) in Physics (Specialization in Electronics) under the Framework of Honours School System

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. PHE-SEC1: Physics Enhancement Skills 50 Marks (2 credits)
2. PHE-SEC2: Computational Physics Skills 50 Marks (2 credits)
3. PHE-SEC3: Electrical Circuits and Network Skills 50 Marks (2 credits)
4. PHE-SEC4: Basic Instrumentation Skills 50 Marks (2 credits)
5. PHE-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)
B.Sc. (Hons.) Physics (Specialization in Electronics) under the Framework of Honours School System

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%).

For the students of B.Sc- I (Hons.) Physics (Specialization in Electronics), who is given project work, the evaluation components (ii), (iii) and (iv) will be replaced by

(i) Performance in the allotted experiments done during the End-semester Practical examination (weightage – 15 %)
(ii) Viva voce by the external examiner (a) related to the practicals Core/DSE courses (weightage - 10%) and evaluation of the project work (weightage – 10 %).
(iii) Continuous evaluation by the internal examiners based on the Viva Voce of the checked practicals (weightage – 10 %) and the project work supervisor (weightage – 15%) for the project work done.

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 evaluation 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 research 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

<table>
<thead>
<tr>
<th>SEMESTER I (Credits = 26, Marks = 650)</th>
<th>SEMESTER II (Credits = 26, Marks = 650)</th>
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<tbody>
<tr>
<td>CT1 PHE-CT1: Mathematical Physics – I</td>
<td>CT3 PHE-CT3: Electricity and Magnetism</td>
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<tr>
<td>CT2 PHE-CT2: Mechanics</td>
<td>CT4 PHE-CT4: Waves and Optics</td>
</tr>
<tr>
<td>PL1 PHE-CP1 : Physics Laboratory-I</td>
<td>PL2 PHE-CP2 : Physics Laboratory-II</td>
</tr>
<tr>
<td>AECC1 PHE-AECC1: English/</td>
<td>AECC2 PHE- AECC2: English/</td>
</tr>
<tr>
<td>Environmental Science</td>
<td>Environmental Science</td>
</tr>
<tr>
<td>GE1*</td>
<td>GE3*</td>
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<tr>
<td>GE2*</td>
<td>GE4*</td>
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<tr>
<th>SEMESTER III</th>
<th>SEMESTER IV</th>
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<tbody>
<tr>
<td>C5 PHE-C5: Mathematical Physics - I</td>
<td>C8 PHE-C8: Mathematical Physics - III</td>
</tr>
<tr>
<td>C6 PHE-C6: Thermal Physics</td>
<td>C9 PHE-C9: Elements of Modern Physics</td>
</tr>
<tr>
<td>C7 PHE-C7: Digital Systems and Applications</td>
<td>C10 PHE-C10: Analog systems and Applications</td>
</tr>
<tr>
<td>SEC1**</td>
<td>SEC2**</td>
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<tr>
<td>GE5*</td>
<td>GE6*</td>
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<tr>
<th>SEMESTER V</th>
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<tr>
<td>C12 PHE-C12: Solid State Physics</td>
<td>C14 PHE-C14: Statistical Mechanics</td>
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<tr>
<td>DSE1#</td>
<td>DSE3#</td>
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<tr>
<td>DSE2#</td>
<td>DSE4#</td>
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</tbody>
</table>

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)

(ii) PHE-SEC1 Physics Workshop Skills
(iii) PHE-SEC2 Computational Physics Skills
3. PHE-SEC3 Electrical circuits and Network Skills
(v) PHE-SEC4 Basic Instrumentation Skills
(vi) PHE-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.)

B PHE-DSE1 Nuclear Physics
C PHE-DSE2 Dissertation and Experimental Techniques Practicals
D PHE-DSE3 Communication Systems
E PHE-DSE4 Atomic and Molecular Physics
F PHE-DSE5 Particle Physics
G PHE-DSE6 Physics of Devices and Instruments

**Courses under these will be offered only if a minimum of 10 students opt for the same

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

<table>
<thead>
<tr>
<th>Bio-Medical Sciences and Physical Sciences</th>
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<tr>
<td>Semesters I</td>
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<td>Semesters II</td>
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</tbody>
</table>
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)
   Credits = 02 each

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.
Semester I

PHE-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)


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

(2 Lectures)

**Suggested Reading**

PHE-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.


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.

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)


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


Suggested Reading

Additional Suggested Reading

PHE-PL1 : PHYSICS LABORATORY-I

Total Lectures : 60 Credits: 04
Max. Marks : 100

Note: The Course content consists of Practicals of the Core Papers, Mechanics, Electricity and Magnetism, and Waves and Optics, and Mathematical Physics–I, which will be performed by the students during the Semesters I and II. 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 measuring instruments 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.
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.
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.
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.
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 highlighted.

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.
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

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<th>Topics</th>
<th>Description with Applications</th>
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<td>Introduction and Overview</td>
<td>Computer architecture and organization, memory and Input/output devices</td>
</tr>
<tr>
<td>Basics of scientific computing</td>
<td>Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow &amp; overflow- emphasize the importance of making equations in terms of dimensionless variables, Iterative methods</td>
</tr>
<tr>
<td>Errors and error Analysis</td>
<td>Truncation and round off errors, Absolute and relative errors, Floating point computations.</td>
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</table>
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**

**Interpolation by Newton Gregory**
- Forward and Backward difference formula, Error estimation of linear interpolation
- Evaluation of trigonometric functions e.g. \(\sin \theta, \cos \theta, \tan \theta\) 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)**
- First order differential equation
- Radioactive decay
- Current in RC, LC circuits with DC source
- Newton’s law of cooling
- Classical equations of motion
- Classical equations of motion
- Attempt following problems using RK 4 order method:
  - Solve the coupled differential equations
  \[
  \frac{dx}{dt} = y + e^{-x} \quad \frac{dy}{dt} = -e^x
  \]
  for four initial conditions
\[ x(0) = 0, \ y(0) = -1, -2, -3, -4. \]
Plot \( x \) vs \( y \) for each of the four initial conditions on the same screen for \( 0 \leq t \leq 15 \)
The differential equation describing the motion of a pendulum is 
\[
\frac{d^2 \theta}{dt^2} = -\frac{g}{L} \sin \theta.
\]
The pendulum is released from rest at an angular displacement \( \alpha \) and \( \Theta'(0) = 0 \). Solve the equation for \( \alpha = 0.1, 0.5 \) and \( 1.0 \) and plot \( \theta \) as a function of time in the range \( 0 \leq t \leq 8\pi \). Also plot the analytic solution valid for small \( \theta \) (\( \sin \theta = \theta \)).

**Suggested Reading (Sections - I, II, III)**
1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal

**Suggested Reading (Section - IV)**
7. An Introduction to Computational Physics, T. Pang, 2nd Edn., 2006, Cambridge Univ. Press
PHE-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.


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.

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 $\mathbf{D}$. Relations between $\mathbf{E}$, $\mathbf{P}$ and $\mathbf{D}$. (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 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 ($\mathbf{M}$). Magnetic Intensity ($\mathbf{H}$). Magnetic Susceptibility and permeability. Relation between $\mathbf{B}$, $\mathbf{H}$, $\mathbf{M}$. Ferromagnetism. B-H curve and hysteresis. (4 Lectures)


(4 Lectures)


(3 Lectures)

**Suggested Reading**

1. Electricity and Magnetism (Berkley, Phys. Course 2), Edward M. Purcell, 1986 McGraw-Hill Education
PHE-C4T: WAVES AND OPTICS

**THEORY**

<table>
<thead>
<tr>
<th>Total Lectures</th>
<th>Credits: 4</th>
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</thead>
<tbody>
<tr>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Max. Marks</td>
<td>100</td>
</tr>
</tbody>
</table>

**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 and unequal frequency and their uses.  

**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.


**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 on a string.


(7 Lectures)


(3 Lectures)


(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)


(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)


(3 Lectures)

**Suggested Reading**


PHE-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. Interested students may also be assigned Project Work (Section V) in lieu of the rest of 4 experiments under the supervision of a teacher.

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 measuring instruments 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.
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.
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 DCVoltages, (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.


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.e. 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.
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

<table>
<thead>
<tr>
<th>Topics</th>
<th>Description with Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction and Overview</td>
<td>Computer architecture and organization, memory and Input/output devices</td>
</tr>
<tr>
<td>Basics of scientific computing</td>
<td>Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow &amp; overflow- emphasize the importance of making equations in terms of dimensionless variables, Iterative methods</td>
</tr>
<tr>
<td>Errors and error Analysis</td>
<td>Truncation and round off errors, Absolute and relative errors, Floating point computations.</td>
</tr>
<tr>
<td>Programs:</td>
<td>Sum &amp; 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,</td>
</tr>
<tr>
<td>Course Title</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Binary search</td>
<td>Area of circle, area of square, volume of sphere, value of pi (π)</td>
</tr>
<tr>
<td>Random number generation</td>
<td>Area of circle, area of square, volume of sphere, value of pi (π)</td>
</tr>
<tr>
<td>Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods</td>
<td>Solution of linear and quadratic equation, solving α = tan α; ( y = \frac{-a^2}{2} ) and ( \sin \theta )</td>
</tr>
<tr>
<td>Interpolation by Newton Gregory</td>
<td>Evaluation of trigonometric functions e.g. ( \sin \theta, \cos \theta, \tan \theta ) etc.</td>
</tr>
<tr>
<td>Numerical differentiation (Forward and Backward difference formula)</td>
<td>Given Position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of B-H Hysteresis loop</td>
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<tr>
<td>Integration (Trapezoidal and Simpson rules), Monte Carlo method</td>
<td>Given Position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of B-H Hysteresis loop</td>
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<tr>
<td>Solution of Ordinary Differential Equations (ODE)</td>
<td>First order differential equation</td>
</tr>
<tr>
<td>First order Differential equation Euler, modified Euler and Runge-Kutta (RK)</td>
<td>First order differential equation</td>
</tr>
<tr>
<td>second and fourth order methods</td>
<td>First order differential equation</td>
</tr>
<tr>
<td>Radioactive decay</td>
<td>First order differential equation</td>
</tr>
<tr>
<td>Current in RC, LC circuits with DC source</td>
<td>First order differential equation</td>
</tr>
<tr>
<td>Newton’s law of cooling</td>
<td>First order differential equation</td>
</tr>
<tr>
<td>Classical equations of motion</td>
<td>First order differential equation</td>
</tr>
<tr>
<td>Attempt following problems using RK 4 order method:</td>
<td>First order differential equation</td>
</tr>
<tr>
<td>Solve the coupled differential equations</td>
<td>First order differential equation</td>
</tr>
<tr>
<td>( \frac{dx}{dt} + y + \frac{x^3}{3} = 0 )</td>
<td>First order differential equation</td>
</tr>
<tr>
<td>for four initial conditions x(0) = 0, y(0) = -1, -2, -3, -4.</td>
<td>First order differential equation</td>
</tr>
<tr>
<td>Plot x vs y for each of the four initial conditions on the same screen for 0 ≤ t ≤ 15</td>
<td>First order differential equation</td>
</tr>
<tr>
<td>The differential equation describing the motion of a pendulum is</td>
<td>First order differential equation</td>
</tr>
<tr>
<td>pendulum is ( \frac{d^2 \theta}{dt^2} + c \sin \theta ) The pendulum is released</td>
<td>First order differential equation</td>
</tr>
</tbody>
</table>
from rest at an angular displacement $\alpha$ and $\theta'(0) = 0$. Solve the equation for $\alpha = 0.1, 0.5$ and $1.0$ and plot $\theta$ as a function of time in the range $0 \leq t \leq 8\pi$. Also plot the analytic solution valid for small $\theta$ ($\sin \theta = \theta$).

SECTION – V

PROJECT WORK

The project work is equivalent to performing 4 experiments and should be of 4-6 weeks duration. It should be based automation of experiments based on the Core Papers, Mechanics, Electricity and Magnetism, and Waves and Optics, and Mathematical Physics–I using electronic tools.

Suggested Reading (Sections - I, II, III)
1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal

Suggested Reading (Section - IV)
7. An Introduction to Computational Physics, T.Pang, 2nd Edn. , 2006,Cambridge Univ. Press
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.


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


Reference Books:

PHE-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., PHE-C5 (P): Mathematical Physics - II, PHE-C6 (P): Thermal Physics, PHE- C7 (P): Digital Systems and Applications, PHE- C8 (P): Mathematical Physics - III, PHE- C9 (P): Elements of Modern Physics, PHE- 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.
<table>
<thead>
<tr>
<th>Topics</th>
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<tbody>
<tr>
<td>Introduction to Numerical computation software Scilab</td>
<td>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 &amp; logical operators, the while loop, for loop, details of loop operations, break &amp; 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).</td>
</tr>
<tr>
<td>Curve fitting, Least square fit, Goodness of fit, standard deviation</td>
<td>Ohms law to calculate R, Hooke’s law to calculate spring constant</td>
</tr>
<tr>
<td>Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalization of</td>
<td>Solution of mesh equations of electric circuits (3 meshes); Solution of coupled spring mass systems (3 masses)</td>
</tr>
<tr>
<td>matrices, Inverse of a matrix, Eigen vectors, eigen values problems</td>
<td>Generating and plotting Legendre Polynomials Generating and plotting Bessel function</td>
</tr>
<tr>
<td>---</td>
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</tr>
</tbody>
</table>
| Generation of Special functions using User defined functions in Scilab | Solution of ODE First order differential equation Radioactive decay Current in RC, LC circuits with DC source Newton’s law of cooling Classical equations of motion Second order Differential Equation Harmonic oscillator (no friction) Damped Harmonic oscillator Over damped Critical damped Oscillatory Forced Harmonic oscillator Transient and Steady state solution Apply above to LCR circuits also Solve \[
    x^2 \frac{d^2 y}{dx^2} - 4x(1 + x) \frac{dy}{dx} + 2(1 + x)y = x^3
\]
with the boundary conditions at \(x = 1, y = \frac{1}{2} e^2, \frac{dy}{dx} = e^2 - 0.5,\) In the range \(1 \leq x \leq 3.\) Plot \(y\) and \(\frac{dy}{dx}\) against \(x\) in the given range on the same graph. | Partial differential equations Partial Differential Equation: Wave equation Heat equation Poisson equation |
B.Sc. (Hons.) in Physics (Specialization in Electronics) under the Framework of Honours School System

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

**Reference Books:**

3. First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett
PHE-C6: THERMAL PHYSICS

PHE-C6 (T) : THERMAL PHYSICS

THEORY

Total Lectures : 60

Credits: 4

Max. Marks : 100


Introduction to Thermodynamics


Equation and Ehrenfest equations.  

**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**


(7 Lectures)


(4 Lectures)


(10 Lectures)

**Reference Books:**


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PHE-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., PHE-C5 (P): Mathematical Physics - II, PHE-C6 (P): Thermal Physics, PHE-C7 (P): Digital Systems and Applications, PHE-C8 (P): Mathematical Physics - III, PHE-C9 (P): Elements of Modern Physics, PHE-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.

16. To determine Mechanical Equivalent of Heat, J, by Callender and Barne’s constant flow method.
17. To measure the coefficient of linear expansion for different metals and alloys.
18. To determine the value of Stefan’s Constant of radiation.
19. To determine the Coefficient of Thermal Conductivity of Cu by Searle’s Apparatus.
20. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom’s Method.
21. To measure the thermal conductivity and thermal diffusivity of a conductor.
22. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton’s disc method.
23. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
24. 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.
25. 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
6. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
7. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal

PHE-C7: DIGITAL SYSTEMS AND APPLICATIONS PHE-C7 (T):
DIGITAL SYSTEMS AND APPLICATIONS THEORY

Total Lectures : 60

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.


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)


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)


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

Reference Books:


PHE-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., PHE-C5 (P): Mathematical Physics - II, PHE-C6 (P): Thermal Physics, PHE-C7 (P): Digital Systems and Applications, PHE-C8 (P): Mathematical Physics - III, PHE-C9 (P): Elements of Modern Physics, PHE-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 measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.
28. To test a Diode and Transistor using a Multimeter.
29. To design a switch (NOT gate) using a transistor.
30. To verify and design AND, OR, NOT and XOR gates using NAND gates.
31. To design a combinational logic system for a specified Truth Table.
32. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
33. To minimize a given logic circuit.
34. Half Adder, Full Adder and 4-bit binary Adder.
35. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
36. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
37. To build JK Master-slave flip-flop using Flip-Flop ICs
38. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
39. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
40. To design an astable multivibrator of given specifications using 555 Timer.
41. To design a monostable multivibrator of given specifications using 555 Timer.
42. Write the following programs using 8085 Microprocessor
21. Addition and subtraction of numbers using direct addressing mode
• Addition and subtraction of numbers using indirect addressing mode
• Multiplication by repeated addition.
• Division by repeated subtraction.
• Handling of 16-bit Numbers.
• Use of CALL and RETURN Instruction.
• Block data handling.
• Other programs (e.g. Parity Check, using interrupts, etc.).

Reference Books:

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.


Integrals Transforms:

Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: standard
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Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform. (15 Lectures)

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

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PHE-C8 (P): MATHEMATICAL PHYSICS-III (PRACTICALS)

Total Lectures : 60

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., PHE-C5 (P): Mathematical Physics - II, PHE-C6 (P): Thermal Physics, PHE- C7 (P): Digital Systems and Applications, PHE- C8 (P): Mathematical Physics - III, PHE- C9 (P): Elements of Modern Physics, PHE- 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

1. Solve differential equations:
   \[ \frac{dy}{dx} = e^{-x} \text{ with } y = 0 \text{ for } x = \]
   \[ 0 \frac{dy}{dx} + e^{-x} y = x^2 \]
   \[ \frac{d^2y}{dt^2} + 2 \frac{dy}{dt} = -y \]
   \[ \frac{d^2y}{dt^2} + e^{-t} \frac{dy}{dt} = -y \]

2. Dirac Delta Function: Evaluate \[ \frac{1}{\sqrt{2\pi}\sigma} \int e^{-\frac{(x-x_0)^2}{2\sigma^2}} (x + 3) dx \] for \( \sigma = 1, 0.1, 0.01 \) and show it tends to 5.

3. Fourier Series:
   Program to sum \[ \sum_{n=1}^{\infty} (0.2)^n \]
   Evaluate the Fourier coefficients of a given periodic function (square wave)

4. Frobenius method and Special functions:
   \[ \int_{-1}^{+1} P_n(\mu)P_m(\mu) d\mu = \delta_{n,m} \]
   Plot \( P_n(x), jv(x) \).
   Show recursion relations.

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

6. Calculation of least square fitting manually without giving weightage to error.
   Confirmation of least square fitting of data through computer program.

7. Evaluation of trigonometric functions e.g. \( \sin \theta \), 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.

8. Compute the \( n^{\text{th}} \) roots of unity for \( n = 2, 3, \) and 4.

9. Find the two square roots of \(-5 + 12j\).

10. Integral transform: FFT of

11. Solve Kirchoff’s Current law for any node of an arbitrary circuit using Laplace’s
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transform.
7. Solve Kirchoff’s Voltage law for any loop of an arbitrary circuit using Laplace’s transform.

Reference Books:

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

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PHE-C9: ELEMENTS OF MODERN PHYSICS

PHE-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, Schrödinger equation and applications, uncertainty principle, nature of nuclear force, nuclear models, fission and fusion, nuclear reactors, stellar energy, Spontaneous and Stimulated emissions and Lasers.


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; Schrödinger 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)


Reference Books:
3. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.

Additional Books for Reference
PHE-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, 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., PHE-C5 (P): Mathematical Physics - II, PHE-C6 (P): Thermal Physics, PHE-C7 (P): Digital Systems and Applications, PHE-C8 (P): Mathematical Physics - III, PHE-C9 (P): Elements of Modern Physics, PHE-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.

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

Reference Books
1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
3. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal

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**PHE-C10: ANALOG SYSTEMS AND APPLICATIONS**

**PHE-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)**

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 $\alpha$ and $\beta$. Relations between $\alpha$ and $\beta$. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions. (6 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)


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)


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

Reference Books:
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17. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

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PHE-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., PHE-C5 (P): Mathematical Physics - II, PHE-C6 (P): Thermal Physics, PHE-C7 (P): Digital Systems and Applications, PHE-C8 (P): Mathematical Physics - III, PHE-C9 (P): Elements of Modern Physics, PHE-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 study I-V characteristics of different diodes - Ge, Si, LED and Zener. Use constant current source for Zener.
28. 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.
29. To study common emitter characteristics of a given transistor and to determine various parameters.
21. Study of I-V & power curves of solar cells, and find maximum power point & efficiency.
22. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
23. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
24. To design a Wien bridge oscillator for given frequency using an op-amp.
25. To design a phase shift oscillator of given specifications using BJT.
26. To study the Colpitt’s oscillator.
27. To design a digital to analog converter (DAC) of given specifications.
28. To study the analog to digital converter (ADC) IC.
29. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain
30. To design inverting amplifier using Op-amp (741,351) and study its frequency response
31. To design non-inverting amplifier using Op-amp (741,351) & study its frequency response
32. To study the zero-crossing detector and comparator
33. To add two dc voltages using Op-amp in inverting and non-inverting mode
34. To design a precision Differential amplifier of given I/O specification using Op-amp.
35. To investigate the use of an op-amp as an Integrator.
36. To investigate the use of an op-amp as a Differentiator.
37. To design a circuit to simulate the solution of a 1st/2nd order differential equation.
38. To draw the characteristics of a given triode and to determine the tube parameters.
39. Calibration of a Si diode, a thermistor and thermocouple for temperature measurements.
40. To measure low resistance by Kelvin’s double bridge/ Carey Foster’s bridge.

Reference Books:

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

PHE-SEC1 to PHE-SEC5

PHE-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 into 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)

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**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:**

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**PHE-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)


(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:

• Exercises on syntax on usage of FORTRAN
• Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN.
1. To print out all natural even/odd numbers between given limits.
2. 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:**
7. To compile a frequency distribution and evaluate mean, standard deviation etc.
8. To evaluate sum of finite series and the area under a curve.
9. To find the product of two matrices.
10. To find a set of prime numbers and Fibonacci series.
11. To write program to open a file and generate data for plotting using Gnuplot.
12. Plotting trajectory of a projectile projected horizontally.
13. Plotting trajectory of a projectile projected making an angle with the horizontally.
14. 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.
15. To find the roots of a quadratic equation.
16. Motion of a projectile using simulation and plot the output for visualization.
17. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.
18. Motion of particle in a central force field and plot the output for visualization.
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(9 Lectures)

Reference Books:

2. Computer Programming in Fortran 77”. V. Rajaraman (Publisher: PHI).

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PHE-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.


(3 Lectures)

(4 Lectures)


(4 Lectures)


(3 Lectures)


(3 Lectures)


(4 Lectures)


(5 Lectures)

Reference Books:
2. A text book of Electrical Technology - A K Theraja
PHE-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 into 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
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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 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:**

10. CRO as a versatile measuring device.
11. Circuit tracing of Laboratory electronic equipment,
12. Use of Digital multimeter/VTVM for measuring voltages
13. Circuit tracing of Laboratory electronic equipment
15. Study the layout of receiver circuit.
16. Trouble shooting a circuit
17. Balancing of bridges

**Laboratory Exercises:**

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

Open Ended Experiments:
1. Using a Dual Trace Oscilloscope
2. Converting the range of a given measuring instrument (voltmeter, ammeter)

Reference Books:
2. Performance and design of AC machines - M G Say ELBS Edn.
8. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

PHE-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

(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)


(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**

1. Demonstration of Training modules on Solar energy, wind energy, etc.
2. Conversion of vibration to voltage using piezoelectric materials
3. Conversion of thermal energy into voltage using thermoelectric modules.
Reference Books:

1. Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi
2. Solar energy - M P Agarwal - S Chand and Co. Ltd.
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.


(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 External Magnetic Fields: Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only). (4 Lectures)


Reference Books:
5. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.

Additional Books for Reference
2. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
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

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

\[ \frac{\hbar^2}{2m} \frac{\partial^2 \psi}{\partial r^2} = - \frac{\hbar^2}{2m} \frac{\partial^2 \psi}{\partial \phi^2} + \frac{\hbar^2}{2m} \frac{\partial^2 \psi}{\partial \theta^2} - \frac{\hbar^2}{2m} \frac{\partial^2 \psi}{\partial \sigma^2} - \frac{\hbar^2}{2m} \frac{\partial^2 \psi}{\partial h^2} \]

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 \( \approx -13.6 \) eV. Take \( e = 3.795 \) (eVÅ)\(^{1/2} \), \( \hbar c = 1973 \) (eVÅ) and \( m = 0.511 \times 10^6 \) eV/c\(^2 \).

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

\[ \frac{\hbar^2}{2m} \frac{\partial^2 \psi}{\partial r^2} = - \frac{\hbar^2}{2m} \frac{\partial^2 \psi}{\partial \phi^2} + \frac{\hbar^2}{2m} \frac{\partial^2 \psi}{\partial \theta^2} - \frac{\hbar^2}{2m} \frac{\partial^2 \psi}{\partial \sigma^2} - \frac{\hbar^2}{2m} \frac{\partial^2 \psi}{\partial h^2} \]

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)\(^{1/2} \), \( m = 0.511 \times 10^6 \) eV/c\(^2 \), and \( a = 3 \)
Å, 5 Å, 7 Å. In these units ħc = 1973 (eV Å). The ground state energy is expected to be above -12 eV in all three cases.

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

\[ \frac{\hbar^2}{2m} = \frac{\hbar^2}{2} - \frac{\hbar^2}{\mu} \]

For the anharmonic oscillator potential

\[ V = \frac{1}{2} \mu \frac{\hbar^2}{m} + \frac{1}{2} \mu \frac{\hbar^2}{m} \]

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^{-3} In these units, cħ = 197.3 MeV fm. The ground state energy is expected to lie between 90 and 110 MeV for all three cases.

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

\[ \frac{\hbar^2}{2m} = \frac{\hbar^2}{2} - \frac{\hbar^2}{\mu} \]

Where \( \mu \) is the reduced mass of the two-atom system for the Morse potential

\[ V = \frac{1}{2} \mu \frac{\hbar^2}{m} + \frac{1}{2} \mu \frac{\hbar^2}{m} \]

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 \times 10^6 eV/C^2, D = 0.755501 eV, \( \alpha = 1.44 \), \( r_o = 0.131349 \) Å

Laboratory based experiments:

5. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency

6. Study of Zeeman effect: with external magnetic field; Hyperfine splitting

7. To show the tunneling effect in tunnel diode using I-V characteristics.
8. Quantum efficiency of CCDs 
9. Study of excitations of a given atom by Franck Hertz set up. 
10. To determine charge to mass ratio (e/m) of an electron by Thomson method. 
11. Determination of dissociation limit of iodine molecule by constant deviation spectrograph 
12. Study of Arc emission spectrum of given samples (Fe and Cu). 

Reference Books: 

PHE-C12: SOLID STATE PHYSICS  

PHE-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. 


(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)*


**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:**
PHE-C12 (P): SOLID STATE PHYSICS
PRACTICALS

Total Lectures : 60                Credits: 2
Max. Marks : 50

Objective: The laboratory experiments forming basis of solid state physics – resistive, dielectric, magnetic, Surface Plasmon Resonance of various materials.

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 - FeCl₂/MnSO₄ 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 using Surface 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 °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
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
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.


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)


(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)


**Reference Books:**
1. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
3. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning

**Additional Books for Reference**
PHE-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.

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarized Light by using a Babinet’s compensator.
4. To study dependence of radiation on angle for a simple Dipole antenna.
5. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
6. To study the reflection, refraction of microwaves
7. To study Polarization and double slit interference in microwaves.
8. To determine the refractive index of liquid by total internal reflection using Wollaston’s air-film.
9. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
10. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
11. To verify the Stefan’s law of radiation and to determine Stefan’s constant.
12. To determine the Boltzmann constant using V-I characteristics of PN junction diode.
13. To study transmission line modeled as LC ladder and find out its propagation constant.
14. To measure the Numerical Aperture of Optical Fiber and study Propagation Loss and Bending Losses.
15. Refractive index of air using Jamin’s Interferometer.
16. To study the Michelson interferometer and its application.
17. To study the intensity profile of the diffraction pattern of single slit and verify the uncertainty principle by using LASER.
Reference Books
3. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal

PHE-C14: STATISTICAL MECHANICS

PHE-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.


(18 Lectures)


(9 Lectures)


(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)


(15 Lectures)

**Reference Books:**


**PHE-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 $Z(\beta)$ 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 $Z(\beta)$, 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
   Press.
3 Introduction to Modern Statistical Mechanics, D. Chandler, Oxford University Press, 1987
5 Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
Discipline Specific Elective Courses (any four) (Credit: 06 each)

PHE-DSE1 to PHE-DSE6

PHE-DSE1: NUCLEAR PHYSICS THEORY

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, interaction 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 excited 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: β⁻, β⁺, 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, Inertantional 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).
The aim of project work in B.Sc (H.S.) 5th semester is to expose the students to Instrumentation, Power Electronics, Microcontroller, Digital communication. It may include development of pulse processing electronic modules, power supplies, software-controlled 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.

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

To design and study the Sample and Hold Circuit.

Design and analyze the Clippers and Clampers circuits using junction diode

To plot the frequency response of a microphone.

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

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

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

To study the characteristics of given voltage doubler and tripler.

To study the clipping and clamping circuits.

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

To determine the distributed capacity of given inductance coil.

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

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

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

To study the characteristics of silicon and GaAs solar cells.

To study the characteristics of LED and photodiode.

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

To design astable multivibrator using transistors.

To study the amplitude modulation.

Reference Books:


PHE-DSE3: COMMUNICATION ELECTRONICS

PHE- DSE3 (T): COMMUNICATION ELECTRONICS

THEORY

Total Lectures: 60

Credits: 4


(8 Lectures)


(10 Lectures)

III. FM Transmission and Reception: Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, FM allocation standards, generation of FM signals, Direct and Indirect FM, Diode reactance modulator, Phase-Locked-Loop, Armstrong method, RC phase shift method, Frequency stabilised reactance FM transmitter. Frequency demodulators, Tuned circuit frequency discriminators; FM stereo multiplexing, FM detection using PLL.

(12 Lectures)

IV. Analog Pulse Modulation: Channel capacity, Sampling theorem, Basic Principles-PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing.

(5 Lectures)

V. Digital transmission – Need for digital transmission, Pulse code modulation, Sampling, Aliasing, quantisation error, Digital carrier modulation and demodulation techniques:
Information capacity, Shannon limit of information capacity, ASK, FSK, PSK, Differential encoder and decoder, Differential PSK, modulators and detectors, Scrambling and descrambling.  

(6 Lectures)

VI. Advanced communication: Overview of picture and sound transmission and reception, channel band width, television standards, Block diagram of T.V. receivers, Concept of colour picture transmission.  

(4 Lectures)

Satellite Communication – Introduction, need, Geosynchronous satellite orbits, geostationary satellite advantages of geostationary satellites. Satellite visibility, transponders (C - Band), path loss, ground station, simplified block diagram of earth station. Uplink and downlink. FDMA, TDMA, CDMA, SDMA (7 Lectures)

Mobile Telephony System – Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only). GPS navigation system (qualitative idea only) (8 Lectures)

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

Books

2. Communication Systems, S. Haykin, 2006, Wiley India
PHE-DSE3 (P): COMMUNICATION ELECTRONICS

PRACTICALS

Total Lectures: 60
Credits: 2
Max. Marks: 50

1. To design an Amplitude Modulator using Transistor
2. To study envelope detector for demodulation of AM signal
3. To study FM - Generator and Detector circuit
4. To study AM Transmitter and Receiver
5. To study FM Transmitter and Receiver
6. To study Time Division Multiplexing (TDM)
7. To study Pulse Amplitude Modulation (PAM)
8. To study Pulse Width Modulation (PWM)
9. To study Pulse Position Modulation (PPM)
10. To study ASK, PSK and FSK modulators

Reference Books:

PHE-DSE4: 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


(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.


(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.


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:
PHE-DSE5: 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, Particle 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 ($\Lambda^0, \Sigma^0, \Sigma^\pm, \Xi^0, \Xi^+, \Omega$), 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
Objective: The students are exposed to physics of hyperfine interactions, 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.


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:

**PHYSICS-DSE3: PHYSICS OF DEVICES AND INSTRUMENTS**

**PHYSICS- DSE3 (T): PHYSICS OF DEVICES AND INSTRUMENTS**

**THEORY**

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<tr>
<th>Total Lectures: 60</th>
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Devices: Characteristic and small signal equivalent circuits of UJT and JFET. Metal-semiconductor Junction. Metal oxide semiconductor (MOS) device. Ideal MOS and Flat Band voltage. SiO$_2$-Si based MOS. MOSFET– their frequency limits. Enhancement and Depletion Mode MOSFETS, CMOS. Charge coupled devices. Tunnel diode. (14 Lectures)

Power supply and Filters: Block Diagram of a Power Supply, Qualitative idea of C and L Filters. IC Regulators, Line and load regulation, Short circuit protection (3 Lectures)

Active and Passive Filters, Low Pass, High Pass, Band Pass and band Reject Filters. (3 Lectures)

Multivibrators: Astable and Monostable Multivibrators using transistors. (3 Lectures)

Phase Locked Loop (PLL): Basic Principles, Phase detector(XOR & edge triggered), Voltage Controlled Oscillator (Basics, varactor). Loop Filter– Function, Loop Filter Circuits, transient response, lock and capture. Basic idea of PLL IC (565 or 4046). (5 Lectures)


**Digital Data Communication Standards:**


Parallel Communications: General Purpose Interface Bus (GPIB), GPIB signals and
Introduction to communication systems: Block diagram of electronic communications system, Need for modulation. Amplitude modulation. Modulation Index. Analysis of Amplitude Modulated wave. Sideband frequencies in AM wave. CE Amplitude Modulator. Demodulation of AM wave using Diode Detector. Basic idea of Frequency, Phase, Pulse and Digital Modulation including ASK, PSK, FSK. (15 lectures)

Reference Books:
1 Physics of Semiconductor Devices, S.M. Sze & K.K. Ng, 3rd Ed. 2008, John Wiley & Sons
8 PC based instrumentation; Concepts & Practice, N. Mathivanan, 2007, Prentice-Hall of India

PHY-C14 (P): PHYSICS OF DEVICES AND INSTRUMENTS

PRACTICALS

Total Lectures : 60
Credits: 2
Max. Marks : 50

1 To design a power supply using bridge rectifier and study effect of C-filter.
2 To design the active Low pass and High pass filters of given specification.
3 To design the active filter (wide band pass and band reject) of given specification.
4 To study the output and transfer characteristics of a JFET.
5 To design a common source JFET Amplifier and study its frequency response.
6 To study the output characteristics of a MOSFET.
7 To study the characteristics of a UJT and design a simple Relaxation Oscillator.
8 To design an Amplitude Modulator using Transistor.
9 To design PWM, PPM, PAM and Pulse code modulation using ICs.
10 To design an Astable multivibrator of given specifications using transistor.
11 To study a PLL IC (Lock and capture range).
12 To study envelope detector for demodulation of AM signal.
13 Study of ASK and FSK modulator.
14 Glow an LED via USB port of PC.
15 Sense the input voltage at a pin of USB port and subsequently glow the LED connected with another pin of USB port.

Reference Books:
5 Introduction to PSPICE using ORCAD for circuits & Electronics, M.H. Rashid, 2003, PHI Learning.
6 PC based instrumentation; Concepts & Practice, N.Mathivanan, 2007, Prentice-Hall of India