Proposed syllabus and Scheme of Examination

for

B.Sc. (Honors) Physics

Submitted

to

University Grants Commission

New Delhi

Under

Choice Based Credit System

April 2015
CHOICE BASED CREDIT SYSTEM

B. SC. HONOURS WITH PHYSICS
Course Structure (Physics-Major)

Details of courses under B.Sc. (Honors)

<table>
<thead>
<tr>
<th>Course</th>
<th>*Credits</th>
<th>Theory + Practical</th>
<th>Theory + Tutorial</th>
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<tr>
<td>I. Core Course</td>
<td>14X4= 56</td>
<td>14X5=70</td>
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<td>(14 Papers)</td>
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<td>Core Course Practical / Tutorial*</td>
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<td>(14 Papers)</td>
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<tr>
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<td>(8 Papers)</td>
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<td>A.1. Discipline Specific Elective</td>
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<td>(4 Papers)</td>
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<tr>
<td>A.2. Discipline Specific Elective</td>
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<tr>
<td>Practical / Tutorial*</td>
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<td>(4 Papers)</td>
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<td>B.2. Generic Elective</td>
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<tr>
<td>Practical / Tutorial*</td>
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<td>4X1=4</td>
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<td>(4 Papers)</td>
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<tr>
<td>• Optional Dissertation or project work in place of one Discipline Specific Elective paper (6 credits) in 6th Semester</td>
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<td>III. Ability Enhancement Courses</td>
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<tr>
<td>1. Ability Enhancement Compulsory</td>
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<tr>
<td>(2 Papers of 2 credit each)</td>
<td>2 X 2=4</td>
<td>2 X 2=4</td>
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<tr>
<td>Environmental Science</td>
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<tr>
<td>English/MIL Communication</td>
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<tr>
<td>2. Ability Enhancement Elective (Skill Based)</td>
<td>2 X 2=4</td>
<td>2 X 2=4</td>
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<td>(Minimum 2)</td>
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<tr>
<td>(2 Papers of 2 credit each)</td>
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<tr>
<td>Total credit</td>
<td>140</td>
<td>140</td>
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</tbody>
</table>

Institute should evolve a system/policy about ECA/ General Interest/Hobby/Sports/NCC/NSS/related courses on its own.

* wherever there is a practical there will be no tutorial and vice-versa
# Proposed Scheme for Choice Based Credit System in B. Sc. Honours (Physics)

<table>
<thead>
<tr>
<th>CORE COURSE (14)</th>
<th>Ability Enhancement Compulsory Course (AECC) (2)</th>
<th>Ability Enhancement Elective Course (AEEC) (2) (Skill Based)</th>
<th>Elective: Discipline Specific DSE (4)</th>
<th>Elective: Generic (GE) (4)</th>
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<tbody>
<tr>
<td>I Mathematical Physics-I (4+4)</td>
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<td>GE-1</td>
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<tr>
<td>Mechanics (4 + 4)</td>
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<tr>
<td>II Electricity &amp; Magnetism (4+4)</td>
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<tr>
<td>Waves and Optics (4 + 4)</td>
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<tr>
<td>III Mathematical Physics-II (4 + 4)</td>
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<tr>
<td>Thermal Physics (4 + 4)</td>
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<tr>
<td>Digital Systems and Applications (4 + 4)</td>
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<td>IV Mathematical Physics–III (4+4)</td>
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<tr>
<td>Elements of Modern Physics (4+4)</td>
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<tr>
<td>Analog Systems &amp; Applications (4+4)</td>
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<tr>
<td>V Quantum Mechanics and Applications (4+4)</td>
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<td>Core course-IX</td>
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<td>Core course-XI</td>
<td>Quantum Mechanics &amp; Applications</td>
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<td>Core Course-XI Practical/Tutorial</td>
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**Core Papers (C): (Credit: 06 each) (1 period/week for tutorials or 4 periods/week for practical)**
1. Mathematical Physics-I (4 + 4)
2. Mechanics (4 + 4)
3. Electricity and Magnetism (4 + 4)
4. Waves and Optics (4 + 4)
5. Mathematical Physics–II (4 + 4)
6. Thermal Physics (4 + 4)
7. Digital Systems and Applications (4 + 4)
8. Mathematical Physics III (4 + 4)
9. Elements of Modern Physics (4 + 4)
10. Analog Systems and Applications (4 + 4)
11. Quantum Mechanics and Applications (4 + 4)
12. Solid State Physics (4 + 4)
13. Electromagnetic Theory (4 + 4)
14. Statistical Mechanics (4 + 4)

**Discipline Specific Elective Papers: (Credit: 06 each) (4 papers to be selected)- DSE 1-4**
1. Experimental Techniques (4) + Lab (4)
2. Embedded systems- Introduction to Microcontroller (4) + Lab (4)
3. Physics of Devices and Instrumentation (4) + Lab (4)
4. Advanced Mathematical Physics (4) + Lab (4)
5. Classical Dynamics (5) + Tutorials (1)
6. Applied Dynamics (4) + Lab (4)
7. Nuclear and Particle Physics (5) + Tutorials (1)
8. Astronomy and Astrophysics (5) + Tutorials (1)
9. Atmospheric Physics (4) + Lab (4)
10. Nano Materials and Applications (4) + Lab (4)
11. Earth Science (5) + Tutorials (1)
12. Medical Physics (4) + Lab (4)
13. Biophysics (5) + Tutorials (1)
14. Dissertation

Note: Universities may include more options or delete some from this list
Other Discipline (Four papers of any one discipline)- GE 1 to GE 4
1. Mathematics (5) + Tut (1)
2. Chemistry (4) + Lab (4)
3. Economics (5) + Tut (1)
4. Computer Science (4) + Lab (4)
Any other discipline of importance

Skill Enhancement Courses (02 to 04 papers) (Credit: 02 each)- SEC1 to SEC4
1. Physics Workshop Skills
2. Computational Physics Skills
3. Electrical circuit network Skills
4. Basic Instrumentation Skills
5. Renewable Energy and Energy harvesting
6. Mechanical Drawing
7. Radiation Safety
8. Applied Optics
9. Weather Forecasting
Note: Universities may include more options or delete some from this list

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Generic Elective Papers (GE) (Minor-Physics) (any four) for other Departments/Disciplines: (Credit: 06 each)
1. Mechanics (4) + Lab (4)
2. Electricity and Magnetism (4) + Lab (4)
3. Thermal Physics (4) + Lab (4)
4. Waves and Optics (4) + Lab (4)
5. Digital, Analog and Instrumentation (4) + Lab (4)
6. Elements of Modern Physics (4) + Lab (4)
7. Mathematical Physics (4) + Lab (4)
8. Solid State Physics (4) + Lab (4)
9. Quantum Mechanics (4) + Lab (4)
10. Embedded System: Introduction to microcontroller (4) + Lab (4)
11. Nuclear and Particle Physics (5) + Tut (1)
Note: Universities may include more options or delete some from this list

Important:
1. Each University/Institute should provide a brief write-up about each paper outlining the salient features, utility, learning objectives and prerequisites.
2. University/Institute can add/delete some experiments of similar nature in the Laboratory papers.
3. The size of the practical group for practical papers is recommended to be 12-15 students.
4. University/Institute can add to the list of reference books given at the end of each paper.
CORE COURSE (HONOURS IN PHYSICS)

Semester I

PHYSICS-C I: MATHEMATICAL PHYSICS-I
(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

The emphasis of course is on applications in solving problems of interest to physicists. The students are to be examined entirely on the basis of problems, seen and unseen.

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). First Order Differential Equations and Integrating Factor. (6 Lectures)


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

Vector Calculus:


Orthogonal Curvilinear Coordinates:
Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. (5 Lectures)
Dirac Delta function and its properties:
Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function. (2 Lectures)

Reference Books:
- An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
- Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
- Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press

PHYSICS LAB- C I LAB:
60 Lectures
The aim of this 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>
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<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>
</tbody>
</table>
Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (If-statement. If-else Statement. Nested if Structure. Else-if Statement. Ternary Operator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop), Arrays (1D & 2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects

Programs:
Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search

Random number generation
Area of circle, area of square, volume of sphere, value of π

Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods
Solution of linear and quadratic equation, solving \( \alpha = \tan \alpha; I = I_o[(\sin \alpha)/\alpha]^2 \) in optics

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

Also attempt some problems on differential equations like:
1. Solve the coupled first order differential equations

\[
\frac{dx}{dt} = y + x - \frac{x^3}{3}, \quad \frac{dy}{dt} = -x,
\]

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 \( 0 \leq t \leq 15 \).

2. The ordinary differential equation describing the motion of a pendulum is

\[
\theta'' = -\sin(\theta)
\]

The pendulum is released from rest at an angular displacement \( \alpha \) i.e. \( \theta(0) = \alpha \), \( \dot{\theta}(0) = 0 \). Use the RK4 method to 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 in the small \( \theta \) (\( \sin(\theta) \approx \theta \)).

3. Solve the differential equation:
\[ x^2 \frac{d^2 y}{dx^2} - 4x(1 + x) \frac{dy}{dx} + 2(1 + x)y = x^3 \]

with the boundary conditions:

at \( x = 1 \), \( y = (1/2) e^3 \), \( \frac{dy}{dx} = - (3/2) e^3 - 0.5 \), in the range \( 1 \leq x \leq 3 \). Plot \( y \) and \( \frac{dy}{dx} \) against \( x \) in the given range. Both should appear on the same graph.

**Referred Books:**

- An Introduction to computational Physics, T.Pang, 2nd Edn., 2006, Cambridge Univ. Press

**PHYSICS-C II: MECHANICS**

(Credits: Theory-04, Practicals-02)

**Theory: 60 Lectures**


(6 Lectures)


(4 Lectures)

**Collisions:** Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames.  

(3 Lectures)


(12 Lectures)

**Elasticity:** Relation between Elastic constants. Twisting torque on a Cylinder or Wire.  

(3 Lectures)

**Fluid Motion:** Kinematics of Moving Fluids: Poiseuille’s Equation for Flow of a Liquid through a Capillary Tube.  

(2 Lectures)
**Gravitation and Central Force Motion:** Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. 

(3 Lectures)


(6 Lectures)

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

(7 Lectures)


(4 Lectures)


(10 Lectures)

**Reference Books:**
- Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.

**Additional Books for Reference**
- Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000

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**PHYSICS LAB-C II LAB**
**60 Lectures**

12
1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To study the random error in observations.
3. To determine the height of a building using a 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
8. To determine the Young's Modulus of a Wire by Optical Lever Method.
9. To determine the Modulus of Rigidity of a Wire by Maxwell’s needle.
10. To determine the elastic Constants of a wire by Searle’s method.
11. To determine the value of g using Bar Pendulum.
12. To determine the value of g using Kater’s Pendulum.

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

Semester II

PHYSICS-C III: ELECTRICITY AND MAGNETISM
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Electric Field and Electric Potential
Electric field: Electric field lines. Electric flux. Gauss’ Law with applications to charge distributions with spherical, cylindrical and planar symmetry. (6 Lectures)


**Dielectric Properties of Matter:** Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector \( D \). Relations between \( E \), \( P \) and \( D \). Gauss’ Law in dielectrics. **(8 Lectures)**


**Magnetic Properties of Matter:** Magnetization vector (\( M \)). Magnetic Intensity(\( H \)). Magnetic Susceptibility and permeability. Relation between \( B \), \( H \), \( M \). Ferromagnetism. \( B \)-\( H \) curve and hysteresis. **(4 Lectures)**


**Electrical Circuits:** AC Circuits: Kirchhoff’s laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit. **(4 Lectures)**

**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)**


**Reference Books:**
- Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
- Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.

**PHYSICS LAB-C III LAB**

60 Lectures
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 study the characteristics of a series RC Circuit.
3. To determine an unknown Low Resistance using Potentiometer.
4. To determine an unknown Low Resistance using Carey Foster’s Bridge.
5. To compare capacitances using De’Sauty’s bridge.
6. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
7. To verify the Thevenin and Norton theorems.
8. To verify the Superposition, and Maximum power transfer theorems.
9. To determine self inductance of a coil by Anderson’s bridge.
10. 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.
11. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
12. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer
14. To determine self-inductance of a coil by Rayleigh’s method.
15. To determine the mutual inductance of two coils by Absolute method.

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

PHYSICS-C IV: WAVES AND OPTICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

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. (5 Lectures)

Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures (1:1 and 1:2) and their uses. (2 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 and its application to rectangular slit. (5 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)

Reference Books

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PHYSICS LAB- C IV LAB
60 Lectures
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 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.

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

Semester III

PHYSICS-C V: MATHEMATICAL PHYSICS-II
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures
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). (4 Lectures)


**Reference Books:**
- Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books

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**PHYSICS LAB-C V LAB**

**60 Lectures**

*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*

<p>| Topics | Description with Applications |</p>
<table>
<thead>
<tr>
<th>Introduction to Numerical computation software Scilab</th>
<th>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).</th>
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<tbody>
<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>
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<tr>
<td>Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen values problems</td>
<td>Solution of mesh equations of electric circuits (3 meshes)</td>
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<td>Solution of ODE</td>
<td>Solution of coupled spring mass systems (3 masses)</td>
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<td>First order Differential equation Euler, modified Euler and Runge-Kutta second order methods</td>
<td>First order differential equation</td>
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<td>Second order differential equation Fixed difference method</td>
<td>• Radioactive decay</td>
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<td>• Current in RC, LC circuits with DC source</td>
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<td>• Newton’s law of cooling</td>
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<td>• Classical equations of motion</td>
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<td>Second order Differential Equation</td>
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<td>• Harmonic oscillator (no friction)</td>
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<td>• Damped Harmonic oscillator</td>
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<td>• Steady state solution</td>
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<td>• Apply above to LCR circuits also</td>
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<td>Using Scicos / xcos</td>
<td>• Generating square wave, sine wave, saw tooth wave</td>
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<td>• Solution to harmonic oscillator</td>
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<td>• Study of beat phenomenon</td>
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<td>• Phase space plots</td>
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**Reference Books:**
- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J.
PHYSICS-C VI: THERMAL PHYSICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures
(Include related problems for each topic)

Introduction to Thermodynamics


Maxwell’s Thermodynamic Relations: Derivations and applications of Maxwell’s Relations, Maxwell’s Relations:(1) Clausius Clapeyron equation, (2) Values of $C_p$-$C_V$,
Kinetic Theory of Gases


Reference Books:
- A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press

PHYSICS LAB- C VI LAB
60 Lectures
1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne’s constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle’s Apparatus.
3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom’s Method.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton’s disc method.
5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
6. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
7. To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.
PHYSICS-C VII: DIGITAL SYSTEMS AND APPLICATIONS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures


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


Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders. (4 Lectures)


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


Introduction to Assembly Language: 1 byte, 2 byte & 3 byte instructions.  

Reference Books:  
- Digital Circuits and systems, Venugopal, 2011, Tata Mcgraw Hill.  

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PHYSICS PRACTICAL-C VII LAB  
60 Lectures  
1. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.  
2. To test a Diode and Transistor using a Multimeter.  
3. To design a switch (NOT gate) using a transistor.  
4. To verify and design AND, OR, NOT and XOR gates using NAND gates.  
5. To design a combinational logic system for a specified Truth Table.  
6. To convert a Boolean expression into logic circuit and design it using logic gate ICs.  
7. To minimize a given logic circuit.  
8. Half Adder, Full Adder and 4-bit binary Adder.  
9. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.  
10. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.  
11. To build JK Master-slave flip-flop using Flip-Flop ICs  
12. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
13. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
14. To design an astable multivibrator of given specifications using 555 Timer.
15. To design a monostable multivibrator of given specifications using 555 Timer.
16. Write the following programs using 8085 Microprocessor
   a) Addition and subtraction of numbers using direct addressing mode
   b) Addition and subtraction of numbers using indirect addressing mode
   c) Multiplication by repeated addition.
   d) Division by repeated subtraction.
   e) Handling of 16-bit Numbers.
   f) Use of CALL and RETURN Instruction.
   g) Block data handling.
   h) Other programs (e.g. Parity Check, using interrupts, etc.).

Reference Books:

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Semester IV

PHYSICS-VIII: MATHEMATICAL PHYSICS-III
(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures
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:
Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation
of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations. (15 Lectures)

Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits. (15 Lectures)

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

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PHYSICS PRACTICAL-C VIII LAB
60 Lectures

Scilab based simulations experiments based on Mathematical Physics problems like

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

2. Dirac Delta Function:
   Evaluate \( \frac{1}{\sqrt{2\pi\sigma^2}} \int e^{-\frac{(x-2)^2}{2\sigma^2}} (x + 3) dx \), 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 \( P_n(x), j_n(x) \)
   Show recursion relation
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. Integral transform: FFT of \( e^{-x^2} \)

Reference Books:
- Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand & Company
- Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing

PHYSICS-C IX: ELEMENTS OF MODERN PHYSICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures


(14 Lectures)

Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from Wave Packets impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle- application to virtual particles and range of an interaction.

(5 Lectures)

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

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

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

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

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


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

Additional Books for Reference
- Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.
- Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill

PHYSICS PRACTICAL-C IX LAB
60 Lectures
1. Measurement of Planck’s constant using black body radiation and photo-detector
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the Planck’s constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the ionization potential of mercury.
7. To determine the absorption lines in the rotational spectrum of Iodine vapour.
8. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
9. To setup the Millikan oil drop apparatus and determine the charge of an electron.
10. To show the tunneling effect in tunnel diode using I-V characteristics.
11. To determine the wavelength of laser source using diffraction of single slit.
12. To determine the wavelength of laser source using diffraction of double slits.
13. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating

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

PHYSICS-C X: ANALOG SYSTEMS AND APPLICATIONS
(Credits: Theory-04, Practicals-02)
Theory: 60 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, (2) Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell. (6 Lectures)


Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of

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

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

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

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

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

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

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

**PHYSICS PRACTICAL-C X LAB**

**60 Lectures**

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

Reference Books:

Semester V

PHYSICS-C XI: QUANTUM MECHANICS AND APPLICATIONS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

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

Time independent Schrodinger equation-Hamiltonian, stationary states and energy
eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy
eigenfunctions; General solution of the time dependent Schrodinger equation in terms of
linear combinations of stationary states; Application to spread of Gaussian wave-packet
for a free particle in one dimension; wave packets, Fourier transforms and momentum
space wavefunction; Position-momentum uncertainty principle. (10 Lectures)
General discussion of bound states in an arbitrary potential: continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle.  (12 Lectures)

Quantum theory of hydrogen-like atoms: time independent Schrödinger 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:
• Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
• Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
• Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press

Additional Books for Reference
• Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
• Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
• Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer

PHYSICS PRACTICAL-C XI LAB
60 Lectures
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:
\[ \frac{d^2y}{dr^2} = A(r)u(r), \quad A(r) = \frac{2m}{\hbar^2} [V(r) - E] \text{ where } V(r) = -\frac{e^2}{r} \]

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

2. Solve the s-wave radial Schrodinger equation for an atom:
\[ \frac{d^2y}{dr^2} = A(r)u(r), \quad A(r) = \frac{2m}{\hbar^2} [V(r) - E] \]
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
\[ V(r) = -\frac{e^2}{r} e^{-r/a} \]
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 \( e = 3.795 \text{ (eV Å)}^{1/2} \), \( m = 0.511 \times 10^6 \text{ eV/c}^2 \), and \( a = 3 \text{ Å}, 5 \text{ Å}, 7 \text{ Å} \). In these units \( \hbar c = 1973 \text{ (eV Å)} \). The ground state energy is expected to be above -12 eV in all three cases.

3. Solve the s-wave radial Schrodinger equation for a particle of mass \( m \):
\[ \frac{d^2y}{dr^2} = A(r)u(r), \quad A(r) = \frac{2m}{\hbar^2} [V(r) - E] \]
For the anharmonic oscillator potential
\[ V(r) = \frac{1}{2} kr^2 + \frac{1}{3} br^3 \]
for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose \( m = 940 \text{ MeV/c}^2 \), \( k = 100 \text{ MeV fm}^{-2} \), \( b = 0, 10, 30 \text{ MeV fm}^{-3} \). In these units \( \hbar = 197.3 \text{ MeV fm} \). The ground state energy I expected to lie between 90 and 110 MeV for all three cases.

4. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule:
\[ \frac{d^2y}{dr^2} = A(r)u(r), \quad A(r) = \frac{2\mu}{\hbar^2} [V(r) - E] \]
Where \( \mu \) is the reduced mass of the two-atom system for the Morse potential
\[ V(r) = D(e^{-2ar'} - e^{-ar'}), \quad r' = \frac{r - r_0}{r} \]
Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function. Take: \( m = 940 \times 10^6 \text{eV/C}^2 \), \( D = 0.755501 \text{ eV} \), \( \alpha = 1.44 \), \( r_0 = 0.131349 \text{ Å} \)

**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

Reference Books:
- An introduction to computational Physics, T.Pang, 2nd Edn., 2006, Cambridge Univ. Press

PHYSICS-C XII: SOLID STATE PHYSICS
(Credits: Theory-04, Practicals-02)
Theory: 60 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)


**Reference Books:**
- Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India

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**PHYSICS PRACTICAL-C XII LAB**

**60 Lectures**
1. Measurement of susceptibility of paramagnetic solution (Quinek’s Tube Method)
2. To measure the Magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the Dielectric Constant of a dielectric Materials with frequency
5. To 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 determine the Hall coefficient of a semiconductor sample.

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

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PHYSICS-C XIII: ELECTROMAGNETIC THEORY
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures


EM Wave Propagation in Unbounded Media: Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere. (10 Lectures)


Single and Multiple Mode Fibres (Concept and Definition Only).  

(3 Lectures)

Reference Books:
- Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
- Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
- Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
- Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

Additional Books for Reference

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PHYSICS PRACTICAL-C XIII LAB

60 Lectures

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.

Reference Books
- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
- Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

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PHYSICS-C XIV: STATISTICAL MECHANICS
(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures


Reference Books:
• Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
• Statistical and Thermal Physics, S. Lekanathan and R.S. Gambhir. 1991, Prentice Hall
• Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
• Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
• An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press

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PHYSICS PRACTICAL-C XIV LAB

60 Lectures

Use C/C++/Scilab for solving the problems based on Statistical Mechanics like
1. Plot Planck’s law for Black Body radiation and compare it with Wein’s Law and Raleigh-Jeans Law at high temperature (room temperature) and low temperature.
2. Plot Specific Heat of Solids by comparing (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature (room temperature) and low temperature and compare them for these two cases.

3. Plot Maxwell-Boltzmann distribution function versus temperature.

4. Plot Fermi-Dirac distribution function versus temperature.

5. Plot Bose-Einstein distribution function versus temperature.

Reference Books:
- Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn. 2007, Wiley India Edition
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer

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PHYSICS-DSE I-IV (ELECTIVES)

PHYSICS-DSE: EXPERIMENTAL TECHNIQUES
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Measurements: Accuracy and precision. Significant figures. Error and uncertainty analysis. Types of errors: Gross error, systematic error, random error. Statistical analysis of data (Arithmetic mean, deviation from mean, average deviation, standard deviation, chi-square) and curve fitting. Guassian distribution. (7 Lectures)


**Digital Multimeter:** Comparison of analog and digital instruments. Block diagram of digital multimeter, principle of measurement of I, V, C. Accuracy and resolution of measurement. **(5 Lectures)**

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

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

**Reference Books:**
- Experimental Methods for Engineers, J.P. Holman, McGraw Hill
- Principles of Electronic Instrumentation, D. Patranabis, PHI Learning Pvt. Ltd.
- Electronic circuits: Handbook of design & applications, U.Tietze, Ch.Schenk, Springer

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**PRACTICAL- DSE LAB: EXPERIMENTAL TECHNIQUES**

**60 Lectures**

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.
9. Comparison of pickup of noise in cables of different types (co-axial, single shielded, double shielded, without shielding) of 2m length, understanding of importance of grounding using function generator of mV level & an oscilloscope.
10. To design and study the Sample and Hold Circuit.
11. Design and analyze the Clippers and Clampers circuits using junction diode
12. To plot the frequency response of a microphone.
13. To measure Q of a coil and influence of frequency, using a Q-meter.
Reference Books:

PHYSICS-DSE: EMBEDDED SYSTEM: INTRODUCTION TO MICROCONTROLLERS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Embedded system introduction: Introduction to embedded systems and general purpose computer systems, architecture of embedded system, classifications, applications and purpose of embedded systems, challenges & design issues in embedded systems, operational and non-operational quality attributes of embedded systems, elemental description of embedded processors and microcontrollers. (6 Lectures)

Review of microprocessors: Organization of Microprocessor based system, 8085µp pin diagram and architecture, concept of data bus and address bus, 8085 programming model, instruction classification, subroutines, stacks and its implementation, delay subroutines, hardware and software interrupts. (4 Lectures)

8051 microcontroller: Introduction and block diagram of 8051 microcontroller, architecture of 8051, overview of 8051 family, 8051 assembly language programming, Program Counter and ROM memory map, Data types and directives, Flag bits and Program Status Word (PSW) register, Jump, loop and call instructions. (12 Lectures)

8051 I/O port programming: Introduction of I/O port programming, pin out diagram of 8051 microcontroller, I/O port pins description & their functions, I/O port programming in 8051 (using assembly language), I/O programming: Bit manipulation. (4 Lectures)

Programming: 8051 addressing modes and accessing memory using various addressing modes, assembly language instructions using each addressing mode, arithmetic and logic instructions, 8051 programming in C: for time delay & I/O operations and manipulation, for arithmetic and logic operations, for ASCII and BCD conversions. (12 Lectures)

Timer and counter programming: Programming 8051 timers, counter programming. (3 Lectures)

Serial port programming with and without interrupt: Introduction to 8051 interrupts, programming timer interrupts, programming external hardware interrupts and serial communication interrupt, interrupt priority in the 8051. (6 Lectures)
Interfacing 8051 microcontroller to peripherals: Parallel and serial ADC, DAC interfacing, LCD interfacing. (2 Lectures)

Programming Embedded Systems: Structure of embedded program, infinite loop, compiling, linking and locating, downloading and debugging. (3 Lectures)

Embedded system design and development: Embedded system development environment, file types generated after cross compilation, disassembler/ decompiler, simulator, emulator and debugging, embedded product development life-cycle, trends in embedded industry. (8 Lectures)

Reference Books:
- Embedded microcomputer system: Real time interfacing, J.W. Valvano, 2000, Brooks/Cole
- Embedded Microcomputer systems: Real time interfacing, J.W. Valvano 2011, Cengage Learning

PRACTICALS- DSE LAB: EMBEDDED SYSTEM:
INTRODUCTION TO MICROCONTROLLERS
60 Lectures

Following experiments using 8051:
1. To find that the given numbers is prime or not.
2. To find the factorial of a number.
3. Write a program to make the two numbers equal by increasing the smallest number and decreasing the largest number.
4. Use one of the four ports of 8051 for O/P interfaced to eight LED’s. Simulate binary counter (8 bit) on LED’s.
5. Program to glow the first four LEDs then next four using TIMER application.
6. Program to rotate the contents of the accumulator first right and then left.
7. Program to run a countdown from 9-0 in the seven segment LED display.
8. To interface seven segment LED display with 8051 microcontroller and display ‘HELP’ in the seven segment LED display.
9. To toggle ’1234’ as ‘1324’ in the seven segment LED display.
10. Interface stepper motor with 8051 and write a program to move the motor through a given angle in clock wise or counter clockwise direction.
11. Application of embedded systems: Temperature measurement, some information on LCD display, interfacing a keyboard.

Reference Books:
Embedded Microcomputer systems: Real time interfacing, J.W. Valvano 2011, Cengage Learning

PHYSICS-DSE: PHYSICS OF DEVICES AND INSTRUMENTS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

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. (15 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:
Serial Communications: RS232, Handshaking, Implementation of RS232 on PC.
Universal Serial Bus (USB): USB standards, Types and elements of USB transfers. Devices (Basic idea of UART).
Parallel Communications: General Purpose Interface Bus (GPIB), GPIB signals and lines, Handshaking and interface management, Implementation of a GPIB on a PC. Basic idea of sending data through a COM port. (4 Lectures)

Introduction to communication systems: Block diagram of electronic communication 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:
- Physics of Semiconductor Devices, S.M. Sze & K.K. Ng, 3rd Ed. 2008, John Wiley & Sons
- PC based instrumentation; Concepts & Practice, N. Mathivanan, 2007, Prentice-Hall of India

PRACTICAL- DSE LAB: PHYSICS OF DEVICES AND INSTRUMENTS
60 Lectures
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.

SPICE/MULTISIM simulations for electrical networks and electronic circuits
1. To verify the Thevenin and Norton Theorems.
2. Design and analyze the series and parallel LCR circuits
3. Design the inverting and non-inverting amplifier using an Op-Amp of given gain
4. Design and Verification of op-amp as integrator and differentiator
5. Design the 1st order active low pass and high pass filters of given cutoff frequency
6. Design a Wein’s Bridge oscillator of given frequency.
7. Design clocked SR and JK Flip-Flop’s using NAND Gates
8. Design 4-bit asynchronous counter using Flip-Flop ICs
9. Design the CE amplifier of a given gain and its frequency response.
10. Design an Astable multivibrator using IC555 of given duty cycle.

Reference Books:
- PC based instrumentation; Concepts & Practice, N.Mathivanan, 2007, Prentice-Hall of India

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PHYSICS-DSE: ADVANCED MATHEMATICAL PHYSICS
(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

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.


Calculus of Variations


Reference Books:

PHYSICS PRACTICAL-DSE LAB: ADVANCED MATHEMATICAL PHYSICS

60 Lectures

Scilab based simulations experiments based on Mathematical Physics problems like
1. Linear algebra:
   - Multiplication of two 3 x 3 matrices.
   - Eigenvalue and eigenvectors of
     \[
     \begin{pmatrix}
     2 & 1 & 1 \\
     1 & 3 & 2 \\
     3 & 1 & 4
     \end{pmatrix};
     \begin{pmatrix}
     1 & -i & 3 + 4i \\
     +i & 2 & 4 \\
     3 - 4i & 4 & 3
     \end{pmatrix};
     \begin{pmatrix}
     2 & -i & 2i \\
     +i & 4 & 3 \\
     -2i & 3 & 5
     \end{pmatrix}
     \]
2. Orthogonal polynomials as eigenfunctions of Hermitian differential operators.
3. Determination of the principal axes of moment of inertia through diagonalization.
5. Lagrangian formulation in Classical Mechanics with constraints.
6. Study of geodesics in Euclidean and other spaces (surface of a sphere, etc).
7. Estimation of ground state energy and wave function of a quantum system.

Reference Books:
PHYSICS-DSE: CLASSICAL DYNAMICS
(Credits: Theory-05, Tutorials-01)
Theory: 75 Lectures

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.


Reference Books:
- Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.

PHYSICS-DSE: APPLIED DYNAMICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures
**Introduction to Dynamical systems**: Definition of a continuous first order dynamical system. The idea of phase space, flows and trajectories. Simple mechanical systems as first order dynamical systems: the free particle, particle under uniform gravity, simple and damped harmonic oscillator. Sketching flows and trajectories in phase space; sketching variables as functions of time, relating the equations and pictures to the underlying physical intuition.

Other examples of dynamical systems –

In Biology: Population models e.g. exponential growth and decay, logistic growth, species competition, predator-prey dynamics, simple genetic circuits

In Chemistry: Rate equations for chemical reactions e.g. auto catalysis, bistability

In Economics: Examples from game theory.

Illustrative examples from other disciplines.

Fixed points, attractors, stability of fixed points, basin of attraction, notion of qualitative analysis of dynamical systems, with applications to the above examples.

Computing and visualizing trajectories on the computer using a software packages. Discrete dynamical systems. The logistic map as an example. (26 Lectures)

**Introduction to Chaos and Fractals**: Examples of 2-dimensional billiard, Projection of the trajectory on momentum space. Sinai Billiard and its variants. Computational visualization of trajectories in the Sinai Billiard. Randomization and ergodicity in the divergence of nearby phase space trajectories, and dependence of time scale of divergence on the size of obstacle. Electron motion in mesoscopic conductors as a chaotic billiard problem. Other examples of chaotic systems; visualization of their trajectories on the computer.

Self similarity and fractal geometry: Fractals in nature – trees, coastlines, earthquakes, etc. Need for fractal dimension to describe self-similar structure. Deterministic fractal vs. self-similar fractal structure. Fractals in dynamics – Serpinski gasket and DLA.


Nonlinear time series analysis and chaos characterization: Detecting chaos from return map. Power spectrum, autocorrelation, Lyapunov exponent, correlation dimension. (20 Lectures)

**Elementary Fluid Dynamics**: Importance of fluids: Fluids in the pure sciences, fluids in technology. Study of fluids: Theoretical approach, experimental fluid dynamics, computational fluid dynamics. Basic physics of fluids: The continuum hypothesis-concept of fluid element or fluid parcel; Definition of a fluid- shear stress; Fluid properties- viscosity, thermal conductivity, mass diffusivity, other fluid properties and equation of state; Flow phenomena- flow dimensionality, steady and unsteady flows, uniform & non-uniform flows, viscous & inviscid flows, incompressible & compressible flows, laminar and turbulent flows, rotational and irrotational flows, separated & unseparated flows. Flow visualization - streamlines, pathlines, Streaklines. (14 Lectures)

**Reference Books**


47
• Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
• An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press, 2002

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PHYSICS PRACTICAL-DSE LAB: APPLIED DYNAMICS
60 Lectures

Laboratory/Computing and visualizing trajectories using software such as Scilab, Maple, Octave, XPPAUT based on Applied Dynamics problems like
1. To determine the coupling coefficient of coupled pendulums.
2. To determine the coupling coefficient of coupled oscillators.
3. To determine the coupling and damping coefficient of damped coupled oscillator.
4. To study population models e.g. exponential growth and decay, logistic growth, species competition, predator-prey dynamics, simple genetic circuits.
5. To study rate equations for chemical reactions e.g. auto catalysis, bistability.
6. To study examples from game theory.
7. Computational visualization of trajectories in the Sinai Billiard.
11. Computational visualization of fractal formations of Fractals in nature – trees, coastlines, earthquakes.

Reference Books
• Nonlinear Dynamics and Chaos, Steven H. Strogatz, Levant Books, Kolkata, 2007
• Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
• An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press, 2002

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PHYSICS-DSE: Nuclear and Particle Physics
(Credits: Theory-05, Tutorials-01)
Theory: 75 Lectures

General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states. (10 Lectures)
Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force. (12 Lectures)

Radioactivity decay: (a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy, (b) β-decay: energy kinematics for β-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. (9 Lectures)

Nuclear Reactions: Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering). (8 Lectures)

Nuclear Astrophysics: Early universe, primordial nucleosynthesis (particle nuclear interactions), stellar nucleosynthesis, concept of gamow window, heavy element production: r- and s- process path. (5 Lectures)

Interaction of Nuclear Radiation with matter: Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter. (6 Lectures)

Detector for Nuclear Radiations: Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector. (6 Lectures)

Particle Accelerators: Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons. (5 Lectures)

Particle physics: Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, color quantum number and gluons. (14 Lectures)

Reference Books:
- Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
- Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
- Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
- Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
- Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic
PHYSICS-DSE: Astronomy & Astrophysics
(Credits: Theory-05, Tutorials-01)
Theory: 75 Lectures


Stellar spectra and classification Structure (Atomic Spectra Revisited, Stellar Spectra, Spectral Types and Their Temperature Dependence, Black Body Approximation, H R Diagram, Luminosity Classification)


Nucleosynthesis and stellar evolution: Cosmic Abundances, Stellar Nucleosynthesis, Evolution of Stars (Evolution on the Main Sequence, Evolution beyond the Main Sequence), Supernovae. Compact stars: Basic Familiarity with Compact Stars, Equation of State and Degenerate Gas of Fermions, Theory of White Dwarf,

(11 Lectures)

**Galaxies**: Galaxy Morphology, Hubble’s Classification of Galaxies, Elliptical Galaxies (The Intrinsic Shapes of Elliptical, de Vaucouleurs Law, Stars and Gas), Spiral and Lenticular Galaxies (Bulges, Disks, Galactic Halo) The Milky Way Galaxy, Gas and Dust in the Galaxy, Spiral Arms, Active Galaxies  

(5 Lectures)

**Active galaxies**: ‘Activities’ of Active Galaxies, How ‘Active’ are the Active Galaxies? Classification of the Active Galaxies, Some Emission Mechanisms Related to the Study of Active Galaxies, Behaviour of Active Galaxies (Quasars and Radio Galaxies, Seyferts, BL Lac Objects and Optically Violent Variables), The Nature of the Central Engine, Unified Model of the Various Active Galaxies  

(8 Lectures)

**Large scale structure & expanding universe**: Cosmic Distance Ladder (An Example from Terrestrial Physics, Distance Measurement using Cepheid Variables), Hubble’s Law (Distance- Velocity Relation), Clusters of Galaxies (Virial theorem and Dark Matter), Friedmann Equation and its Solutions, Early Universe and Nucleosynthesis (Cosmic Background Radiation, Evolving vs. Steady State Universe)  

(8 Lectures)

**Reference Books:**

- Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer
- Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.

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**PHYSICS-DSE: Atmospheric Physics**  
**(Credits: Theory-04, Practicals-02)**

**Theory: 60 Lectures**

**General features of Earth’s atmosphere**: Thermal structure of the Earth’s Atmosphere, Ionosphere, Composition of atmosphere, Hydrostatic equation, Atmospheric Thermodynamics, Greenhouse effect and effective temperature of Earth, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations, including
RS/RW, meteorological processes and different systems, fronts, Cyclones and anticyclones, thunderstorms. (12 Lectures)

**Atmospheric Dynamics:** Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity, Atmospheric oscillations, Mesoscale circulations, The general circulations, Tropical dynamics. (12 Lectures)

**Atmospheric Waves:** Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a nonhomogeneous medium, Lamb wave, Rossby waves and its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration (12 Lectures)

**Atmospheric Radar and Lidar:** Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Application of radars to study atmospheric phenomena, Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques. (12 Lectures)

**Atmospheric Aerosols:** Spectral distribution of the solar radiation, Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Radiative and health effects, Observational techniques for aerosols, Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Bouguert-Lambert law, Principles of radiometry, Optical phenomena in atmosphere, Aerosol studies using Lidars. (12 Lectures)

**Reference Books:**
- An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004

**PRACTICALS-DSE LAB: Atmospheric Physics**

60 Lectures

1. Numerical Simulation for atmospheric waves using dispersion relations
2. Atmospheric gravity waves
   (b) Kelvin waves
   (c) Rossby waves, and mountain waves
3. Offline and online processing of radar data
   (a) VHF radar,
   (b) X-band radar, and
Offline and online processing of LIDAR data
5. Radiosonde data and its interpretation in terms of atmospheric parameters using vertical profiles in different regions of the globe.
6. Handling of satellite data and plotting of atmospheric parameters using radio occultation technique
7. Time series analysis of temperature using long term data over metropolitan cities in India – an approach to understand the climate change

Reference Books:
- An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004

PHYSICS-DSE: Nano Materials and Applications
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

NANOSCALE SYSTEMS: Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods), Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement: Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences.


Reference books:  
1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).  

PRACTICALS-DSE LAB: Nano Materials and Applications  
60 Lectures  
1. Synthesis of metal nanoparticles by chemical route.  
2. Synthesis of semiconductor nanoparticles.  
3. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.  
4. XRD pattern of nanomaterials and estimation of particle size.  
5. To study the effect of size on color of nanomaterials.  
6. To prepare composite of CNTs with other materials.  
8. Prepare a disc of ceramic of a compound using ball milling, pressing and sintering, and study its XRD.  
9. Fabricate a thin film of nanoparticles by spin coating (or chemical route) and study transmittance spectra in UV-Visible region.  
10. Prepare a thin film capacitor and measure capacitance as a function of temperature or frequency.  
11. Fabricate a PN diode by diffusing Al over the surface of N-type Si and study its V-I characteristic.  

Reference Books:  
1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).  

PHYSICS-DSE: Earth Science  
(Credits: Theory-05, Tutorials-01)  
Theory: 75 Lectures  
1. The Earth and the Universe: (17 Lectures)
(a) Origin of universe, creation of elements and earth. A Holistic understanding of our dynamic planet through Astronomy, Geology, Meteorology and Oceanography. Introduction to various branches of Earth Sciences.

(b) General characteristics and origin of the Universe. The Milky Way galaxy, solar system, Earth’s orbit and spin, the Moon’s orbit and spin. The terrestrial and Jovian planets. Meteorites & Asteroids. Earth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age.

(c) Energy and particle fluxes incident on the Earth.

(d) The Cosmic Microwave Background.

2. Structure: (18 Lectures)
   (a) The Solid Earth: Mass, dimensions, shape and topography, internal structure, magnetic field, geothermal energy. How do we learn about Earth’s interior?
   (b) The Hydrosphere: The oceans, their extent, depth, volume, chemical composition. River systems.
   (c) The Atmosphere: variation of temperature, density and composition with altitude, clouds.
   (d) The Cryosphere: Polar caps and ice sheets. Mountain glaciers.

3. Dynamical Processes: (18 Lectures)
   Climate:
   i. Earth’s temperature and greenhouse effect.
   ii. Paleoclimate and recent climate changes.
   iii. The Indian monsoon system.
   (d) Biosphere: Water cycle, Carbon cycle, Nitrogen cycle, Phosphorous cycle. The role of cycles in maintaining a steady state.

4. Evolution: (18 Lectures)
   Nature of stratigraphic records, Standard stratigraphic time scale and introduction to the concept of time in geological studies. Introduction to geochronological methods in their application in geological studies. History of development in concepts of uniformitarianism, catastrophism and neptunism. Law of superposition and faunal succession. Introduction to the geology and geomorphology of Indian subcontinent.
   1. Time line of major geological and biological events.
3. Role of the biosphere in shaping the environment.

5. **Disturbing the Earth – Contemporary dilemmas** (4 Lectures)
   (a) Human population growth.
   (b) Atmosphere: Green house gas emissions, climate change, air pollution.
   (c) Hydrosphere: Fresh water depletion.
   (d) Geosphere: Chemical effluents, nuclear waste.
   (e) Biosphere: Biodiversity loss. Deforestation. Robustness and fragility of ecosystems.

**Reference Books:**

**PHYSICS-DSE: Medical Physics**
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

**PHYSICS OF THE BODY-I**
**Mechanics of the body:** Skeleton, forces, and body stability. Muscles and the dynamics of body movement, Physics of body crashing. **Energy household of the body:** Energy balance in the body, Energy consumption of the body, Heat losses of the body, **Pressure system of the body:** Physics of breathing, Physics of cardiovascular system. (10 Lectures)

**PHYSICS OF THE BODY-II**
**Acoustics of the body:** Nature and characteristics of sound, Production of speech, Physics of the ear, Diagnostics with sound and ultrasound. **Optical system of the body:** Physics of the eye. **Electrical system of the body:** Physics of the nervous system, Electrical signals and information transfer. (10 Lectures)

**PHYSICS OF DIAGNOSTIC AND THERAPEUTIC SYSTEMS-I**

**RADIATION PHYSICS:** Radiation units - exposure - absorbed dose – units: rad, gray -


9 Lectures


6 Lectures


6 Lectures

PHYSICS OF DIAGNOSTIC AND THERAPEUTIC SYSTEMS-II
Diagnostic nuclear medicine: Radiopharmaceuticals for radioisotope imaging, Radioisotope imaging equipment, Single photon and positron emission tomography. Therapeutic nuclear medicine: Interaction between radiation and matter Dose and isodose in radiation treatment

5 Lectures

Reference Books:
- Medical Physics, J.R. Cameron and J.G.Skofronick, Wiley (1978)
- Christensen’s Physics of Diagnostic Radiology: Curry, Dowdey and Murry - Lippincot Williams and Wilkins (1990)
- The Physics of Radiology-H E Johns and Cunningham.

PHYSICS-DSE LAB: Medical Physics
60 Lectures
1. Understanding the working of a manual Hg Blood Pressure monitor and measure the Blood Pressure.
2. Understanding the working of a manual optical eye-testing machine and to learn eye-testing procedure.
3. Correction of Myopia (short sightedness) using a combination of lenses on an optical bench/breadboard.
4. Correction of Hypermetropia/Hyperopia (long sightedness) using a combination of lenses on an optical bench/breadboard.
5. To learn working of Thermoluminescent dosimeter (TLD) badges and measure the background radiation.
6. Familiarization with Geiger-Muller (GM) Counter and to measure background radiation.
7. Familiarization with Radiation meter and to measure background radiation.
8. Familiarization with the construction of speaker-receiver system and to design a speaker-receiver system of given specification.

Reference Books:
- Christensen’s Physics of Diagnostic Radiology: Curry, Dowdey and Murry - Lippincot Williams and Wilkins (1990)
- The Physics of Radiology-H E Johns and Cunningham.

PHYSICS-DSE: Bio-Physics
(Credits: Theory-05, Tutorials-01)
Theory: 75 Lectures

Building Blocks & Structure of Living State: Atoms and ions, molecules essential for life, what is life. Living state interactions: Forces and molecular bonds, electric & thermal interactions, electric dipoles, casimir interactions, domains of physics in biology. (18 Lectures)


Open systems and chemical thermodynamics: Enthalpy, Gibbs Free Energy and chemical potential, activation energy and rate constants, enzymatic reactions, ATP hydrolysis & synthesis, Entropy of mixing, The grand canonical ensemble, Hemoglobin.
**Diffusion and transport** Maxwell-Boltzmann statistics, Fick’s law of diffusion, sedimentation of Cell Cultures, diffusion in a centrifuge, diffusion in an electric field, Lateral diffusion in membranes, Navier stokes equation, low Reynold’s Number Transport, Active and passive membrane transport. (19 Lectures)

**Fluids:** Laminar and turbulent fluid flow, Bernoulli’s equation, equation of continuity, venture effect, Fluid dynamics of circulatory systems, capillary action. **Bioenergetics and Molecular motors:** Kinesins, Dyneins, and microtubule dynamics, Brownian motion, ATP synthesis in Mitochondria, Photosynthesis in Chloroplasts, Light absorption in biomolecules, vibrational spectra of bio-biomolecules. (19 Lectures)

**Reference Books:**
- Introductory Biophysics, J. Claycomb, JQP Tran, Jones & Bartelett Publishers
- Aspects of Biophysics, Hugh S W, John Willy and Sons.
- Essentials of Biophysics by P Narayanan, New Age International

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**Skill Enhancement Course (any four) (Credit: 02 each)- SEC1 to SEC4**

**PHYSICS WORKSHOP SKILL**
**(Credits: 02)**
**30 Lectures**
The aim of this course is to enable the students to familiar and experience with various mechanical and electrical tools through hands-on mode

**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)

**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:**

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

**COMPUTATIONAL PHYSICS**  
(Credits: 02)

**Theory:** 30 Lectures

*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.

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

(4 Lectures)

**Scientific Programming:** Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN, Basic elements of FORTRAN: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of
writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems. (5 Lectures)

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

**Programming:**
1. Exercises on syntax on usage of FORTRAN
2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN.
3. To print out all natural even/odd numbers between given limits.
4. 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:**
1. To compile a frequency distribution and evaluate mean, standard deviation etc.
2. To evaluate sum of finite series and the area under a curve.
3. To find the product of two matrices
4. To find a set of prime numbers and Fibonacci series.
5. To write program to open a file and generate data for plotting using Gnuplot.
6. Plotting trajectory of a projectile projected horizontally.
7. Plotting trajectory of a projectile projected making an angle with the horizontally.
8. 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.
9. To find the roots of a quadratic equation.
10. Motion of a projectile using simulation and plot the output for visualization.
11. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.
12. Motion of particle in a central force field and plot the output for visualization. (9 Lectures)
Reference Books:
- Computer Programming in Fortran 77”, V. Rajaraman (Publisher: PHI).
- Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010)

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ELECTRICAL CIRCUIT NETWORK SKILLS
(Credits: 02)

Theory: 30 Lectures

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


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

Electric Motors: Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters & motors. Speed & power of ac motor. (4 Lectures)

Solid-State Devices: Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources (3 Lectures)


**Reference Books:**
- A text book in Electrical Technology - B L Theraja - S Chand & Co.
- A text book of Electrical Technology - A K Theraja
- Performance and design of AC machines - M G Say ELBS Edn.

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**BASIC INSTRUMENTATION SKILLS**  
_Credits: 02_

**Theory:** 30 Lectures  
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.

**Basic of Measurement:** Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. **Multimeter:** Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance. (4 Lectures)

**Electronic Voltmeter:** Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage measurement (block diagram only). Specifications of an electronic Voltmeter/Multimeter and their significance. **AC millivoltmeter:** Type of AC millivoltmeters: Amplifier- rectifier, and rectifier- amplifier. Block diagram ac millivoltmeter, specifications and their significance. (4 Lectures)

**Cathode Ray Oscilloscope:** Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only— no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance. (6 Lectures)

Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working. (3 Lectures)

**Signal Generators and Analysis Instruments:** Block diagram, explanation and specifications of low frequency signal generators. pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis. (4 Lectures)
Impedance Bridges & Q-Meters: Block diagram of bridge. working principles of basic (balancing type) RLC bridge. Specifications of RLC bridge. Block diagram & working principles of a Q- Meter. Digital LCR bridges.  (3 Lectures)


Digital 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:
1. Use of an oscilloscope.
2. CRO as a versatile measuring device.
3. Circuit tracing of Laboratory electronic equipment,
4. Use of Digital multimeter/VTVM for measuring voltages
5. Circuit tracing of Laboratory electronic equipment,
7. Study the layout of receiver circuit.
8. Trouble shooting a circuit
9. 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:
- A text book in Electrical Technology - B L Theraja - S Chand and Co.
- Performance and design of AC machines - M G Say ELBS Edn.
- Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
- Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India
RENEWABLE ENERGY AND ENERGY HARVESTING
(Credits: 02)

Theory: 30 Lectures

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

Fossil fuels and Alternate Sources of energy: Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity. (3 Lectures)

Solar energy: Solar energy, its importance, storage of solar energy, solar pond, non convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems. (6 Lectures)

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


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:
- Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi
- Solar energy - M P Agarwal - S Chand and Co. Ltd.
- J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).

MECHANICAL DRAWING
(Credits: 02)
Theory: 30 Lectures


(4 Lectures)


(6 Lectures)


(4 Lectures)

CAD Drawing: Introduction to CAD and Auto CAD, precision drawing and drawing aids, Geometric shapes, Demonstrating CAD- specific skills (graphical user interface. Create, retrieve, edit, and use symbol libraries. Use inquiry commands to extract drawing data). Control entity properties. Demonstrating basic skills to produce 2-D and 3-D drawings. 3D modeling with Auto CAD (surfaces and solids), 3D modeling with sketch up, annotating in Auto CAD with text and hatching, layers, templates & design center, advanced plotting (layouts, viewports), office standards, dimensioning, internet and collaboration, Blocks, Drafting symbols, attributes, extracting data. basic printing, editing tools, Plot/Print drawing to appropriate scale.

(16 Lectures)

Reference Books:
- K. Venugopal, and V. Raja Prabhu. Engineering Graphic, New Age International
- Architectural Design with Sketchup/Alexander Schreyer/John Wiley & Sons/ISBN:
Radiation Safety
(Credits: 02)
Theory: 30 Lectures

The aim of this course is for awareness and understanding regarding radiation hazards and safety. The list of laboratory skills and experiments listed below the course are to be done in continuation of the topics

Basics of Atomic and Nuclear Physics: Basic concept of atomic structure; X rays characteristic and production; concept of bremsstrahlung and auger electron, The composition of nucleus and its properties, mass number, isotopes of element, spin, binding energy, stable and unstable isotopes, law of radioactive decay, Mean life and half life, basic concept of alpha, beta and gamma decay, concept of cross section and kinematics of nuclear reactions, types of nuclear reaction, Fusion, fission. (6 Lectures)


Radiation detection and monitoring devices: Radiation Quantities and Units: Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, Annual Limit of Intake (ALI) and derived Air Concentration (DAC). Radiation detection: Basic concept and working principle of gas detectors (Ionization Chambers, Proportional Counter, Multi-Wire Proportional Counters (MWPC) and Gieger Muller Counter), Scintillation Detectors (Inorganic and Organic Scintillators), Solid States Detectors and Neutron Detectors, Thermo luminescent Dosimetry. (7 Lectures)


Application of nuclear techniques: Application in medical science (e.g., MRI, PET, Projection Imaging Gamma Camera, radiation therapy), Archaeology, Art, Crime detection, Mining and oil. Industrial Uses: Tracing, Gauging, Material Modification, Sterization, Food preservation. (5 Lectures)
Experiments:
1. Study the background radiation levels using Radiation meter

Characteristics of Geiger Muller (GM) Counter:
2) Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).
3) Study of counting statistics using background radiation using GM counter.
4) Study of radiation in various materials (e.g. KSO4 etc.). Investigation of possible radiation in different routine materials by operating GM at operating voltage.
6) Detection of \(\alpha\) particles using reference source & determining its half life using spark counter
7) Gamma spectrum of Gas Light mantle (Source of Thorium)

Reference Books:
2. G.F.Knoll, Radiation detection and measurements
3. Thermoluminesence Dosimetry, Mcknlay, A.F., Bristol, Adam Hilger (Medical Physics Handbook 5)
8. NCRP, ICRP, ICRU, IAEA, AERB Publications.

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APPLIED OPTICS
(Credits: 02)
THEORY: 30 Lectures

Theory includes only qualitative explanation. Minimum five experiments should be performed covering minimum three sections.

<table>
<thead>
<tr>
<th>(i) Sources and Detectors</th>
<th>(9 Periods)</th>
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Experiments on Lasers:
a. Determination of the grating radial spacing of the Compact Disc (CD) by
reflection using He-Ne or solid state laser.

b. To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid state laser.
c. To find the polarization angle of laser light using polarizer and analyzer
d. Thermal expansion of quartz using laser

**Experiments on Semiconductor Sources and Detectors:**

a. V-I characteristics of LED
b. Study the characteristics of solid state laser
c. Study the characteristics of LDR
d. Photovoltaic Cell
e. Characteristics of IR sensor
(ii) Fourier Optics (6 Periods)

Concept of Spatial frequency filtering, Fourier transforming property of a thin lens

Experiments on Fourier Optics:

a. Fourier optic and image processing
   1. Optical image addition/subtraction
   2. Optical image differentiation
   3. Fourier optical filtering
   4. Construction of an optical 4f system

b. Fourier Transform Spectroscopy

Fourier Transform Spectroscopy (FTS) is a powerful method for measuring emission and absorption spectra, with wide application in atmospheric remote sensing, NMR spectrometry and forensic science.

Experiment:

To study the interference pattern from a Michelson interferometer as a function of mirror separation in the interferometer. The resulting interferogram is the Fourier transform of the power spectrum of the source. Analysis of experimental interferograms allows one to determine the transmission characteristics of several interference filters. Computer simulation can also be done.

(iii) Holography (6 Periods)

Basic principle and theory: coherence, resolution, Types of holograms, white light reflection hologram, application of holography in microscopy, interferometry, and character recognition

Experiments on Holography and interferometry:

1. Recording and reconstructing holograms
2. Constructing a Michelson interferometer or a Fabry Perot interferometer
3. Measuring the refractive index of air
4. Constructing a Sagnac interferometer
5. Constructing a Mach-Zehnder interferometer
6. White light Hologram

(iv) Photonics: Fibre Optics (9 Periods)

Optical fibres and their properties, Principal of light propagation through a fibre, The numerical aperture, Attenuation in optical fibre and attenuation limit, Single mode and multimode fibres, Fibre optic sensors: Fibre Bragg Grating

Experiments on Photonics: Fibre Optics

a. To measure the numerical aperture of an optical fibre
b. To study the variation of the bending loss in a multimode fibre
c. To determine the mode field diameter (MFD) of fundamental mode in a single-mode fibre by measurements of its far field Gaussian pattern
d. To measure the near field intensity profile of a fibre and study its refractive index profile
e. To determine the power loss at a splice between two multimode fibre

Reference Books:

WEATHER FORECASTING
(Credits: 02)

Theory: 30 Lectures

The aim of this course is not just to impart theoretical knowledge to the students but to enable them to develop an awareness and understanding regarding the causes and effects of different weather phenomenon and basic forecasting techniques.

Introduction to atmosphere: Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature; requirements to measure air temperature; temperature sensors: types; atmospheric pressure: its measurement; cyclones and anticyclones: its characteristics. (9 Periods)

Measuring the weather: Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall, radiation: absorption, emission and scattering in atmosphere; radiation laws. (4 Periods)

Weather systems: Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes. (3 Periods)

Climate and Climate Change: Climate: its classification; causes of climate change; global warming and its outcomes; air pollution; aerosols, ozone depletion, acid rain, environmental issues related to climate. (6 Periods)

Basics of weather forecasting: Weather forecasting: analysis and its historical background; need of measuring weather; types of weather forecasting; weather forecasting methods; criteria of choosing weather station; basics of choosing site and exposure; satellites observations in weather forecasting; weather maps; uncertainty and predictability; probability forecasts. (8 Periods)

Demonstrations and Experiments:
1. Study of synoptic charts & weather reports, working principle of weather station.
2. Processing and analysis of weather data.
(a) To calculate the sunniest time of the year.
(b) To study the variation of rainfall amount and intensity by wind direction.
(c) To observe the sunniest/driest day of the week.
(d) To examine the maximum and minimum temperature throughout the year.
(e) To evaluate the relative humidity of the day.
(f) To examine the rainfall amount month wise.


4. Formats and elements in different types of weather forecasts/ warning (both aviation and non aviation)

**Reference books:**

Generic Elective Papers (GE) (Minor-Physics) (any four) for other Departments/Disciplines: (Credit: 06 each)

GE: MECHANICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Vectors: Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter. (4 Lectures)

Ordinary Differential Equations: 1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients. (6 Lectures)


Rotational Motion: Angular velocity and angular momentum. Torque. Conservation of angular momentum. (5 Lectures)


Elasticity: Hooke’s law - Stress-strain diagram - Elastic moduli-Relation between elastic constants - Poisson’s Ratio-Expression for Poisson’s ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire - Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion - Torsional
pendulum—Determination of Rigidity modulus and moment of inertia - q, η and σ by Searles method.  


Note: Students are not familiar with vector calculus. Hence all examples involve differentiation either in one dimension or with respect to the radial coordinate  

Reference Books:  
• University Physics. F.W. Sears, M.W. Zemansky and H.D. Young, 13/e, 1986. Addison-Wesley  
• Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley  
• University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.  

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PHYSICS LAB: GE LAB: MECHANICS  
60 Lectures  
1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.  
2. To determine the Height of a Building using a Sextant.  
3. To determine the Moment of Inertia of a Flywheel.  
4. To determine the Young's Modulus of a Wire by Optical Lever Method.  
5. To determine the Modulus of Rigidity of a Wire by Maxwell’s needle.  
6. To determine the Elastic Constants of a Wire by Searle’s method.  
7. To determine g by Bar Pendulum.  
8. To determine g by Kater’s Pendulum.  
9. To study the Motion of a Spring and calculate (a) Spring Constant, (b) g.  

Reference Books:  
• Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.  

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GE: ELECTRICITY AND MAGNETISM  
(Credits: Theory-04, Practicals-02)  
Theory: 60 Lectures
Vector Analysis: Scalar and Vector product, gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).

(12 Lectures)

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

(22 Lectures)

Magnetism:

(10 Lectures)


(6 Lectures)

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

(10 Lectures)

Reference Books:
- Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
- D.J.Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings.

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

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

GE: THERMAL PHYSICS AND STATISTICAL MECHANICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures


Thermodynamical Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell’s relations and applications - Joule-Thompson Effect, Clausius-Clapeyron Equation, Expression for $(C_P - C_V)$, $C_P/C_V$, TdS equations. (10 Lectures)

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

**Theory of Radiation:** Blackbody radiation, Spectral distribution, Concept of Energy
Density, Derivation of Planck's law, Deduction of Wien’s distribution law, Rayleigh-
Jeans Law, Stefan Boltzmann Law and Wien’s displacement law from Planck’s law.

(10 Lectures)

**Statistical Mechanics:** Maxwell-Boltzmann law - distribution of velocity - Quantum
statistics - Phase space - Fermi-Dirac distribution law - electron gas - Bose-Einstein

(12 Lectures)

**Reference Books:**
- Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.
- Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears and
  G.L. Salinger. 1988, Narosa

**GE LAB: THERMAL PHYSICS AND STATISTICAL MECHANICS**

60 Lectures

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

**Reference Books:**
- Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971,
  Asia Publishing House.
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th
GE: WAVES AND OPTICS  
(Credits: Theory-04, Practicals-02)  
Theory: 60 Lectures

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

Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures (1:1 and 1:2) and their uses.  
(2 Lectures)

(7 Lectures)

(6 Lectures)

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

(3 Lectures)

(10 Lectures)

Michelson’s Interferometer: (1) Idea of form of fringes (no theory needed), (2) Determination of wavelength, (3) Wavelength difference, (4) Refractive index, and (5) Visibility of fringes.  
(3 Lectures)
**Diffraction:** Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis.  
(14 Lectures)

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

**Reference Books:**
- Principles of Optics, B.K. Mathur, 1995, Gopal Printing
- University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison-Wesley

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**GE LAB: WAVES AND OPTICS**

**60 Lectures**

1. To investigate the motion of coupled oscillators
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde’s Experiment and to verify $\lambda^2 = T$ Law.
3. To study Lissajous Figures
4. Familiarization with Schuster’s focussing; determination of angle of prism.
5. To determine the Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille’s method).
6. To determine the Refractive Index of the Material of a Prism using Sodium Light.
7. To determine Dispersive Power of the Material of a Prism using Mercury Light
8. To determine the value of Cauchy Constants.
10. To determine wavelength of sodium light using Fresnel Biprism.
12. To determine the wavelength of Laser light using Diffraction of Single Slit.
13. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating
15. To measure the intensity using photosensor and laser in diffraction patterns of single and double slits.

**Reference Books:**
- Advanced Practical Physics for students, B.L. Flint and H.T.Worsnop, 1971, Asia Publishing House.
GE: DIGITAL, ANALOG CIRCUITS AND INSTRUMENTATION
(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

UNIT-1: Digital Circuits
Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary
and Binary to Decimal Conversion, AND, OR and NOT Gates (Realization using
Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR
Gates. (4 Lectures)

De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean
Table into an Equivalent Logic Circuit by (1) Sum of Products Method and (2)
Karnaugh Map. (5 Lectures)

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

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

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE
and CC Configurations. Current gains α and β. Relations between α and β. Load Line
analysis of Transistors. DC Load line & Q-point. Active, Cutoff & Saturation regions.
Voltage Divider Bias Circuit for CE Amplifier. h-parameter Equivalent Circuit.
Analysis of single-stage CE amplifier using hybrid Model. Input & output Impedance.
Current, Voltage and Power gains. Class A, B & C Amplifiers. (12 Lectures)

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

Sinusoidal Oscillators: Barkhausen's Criterion for Self-sustained Oscillations.
Determination of Frequency of RC Oscillator (5 Lectures)
UNIT-4: Instrumentations: Introduction to CRO: Block Diagram of CRO. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference. (3 Lectures)
Power Supply: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers Calculation of Ripple Factor and Rectification Efficiency, Basic idea about capacitor filter, Zener Diode and Voltage Regulation. (6 Lectures)
Timer IC: IC 555 Pin diagram and its application as Astable and Monostable Multivibrator. (3 Lectures)

Reference Books:
- Modern Electronic Instrumentation and Measurement Tech., Helfrick and Cooper, 1990, PHI Learning

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

Reference Books:
GE: ELEMENTS OF MODERN PHYSICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Planck’s quantum, Planck’s constant and light as a collection of photons; Photoelectric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment.  

(8 Lectures)

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

(4 Lectures)

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

(4 Lectures)

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

(11 Lectures)

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

(12 Lectures)

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

(6 Lectures)

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

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

**Reference Books:**
- Six Ideas that Shaped Physics: Particle Behave like Waves, Thomas A. Moore, 2003, McGraw Hill

**GE LAB: ELEMENTS OF MODERN PHYSICS**

**60 Lectures**

1. To determine value of Boltzmann constant using V-I characteristic of PN diode.
2. To determine work function of material of filament of directly heated vacuum diode.
3. To determine the ionization potential of mercury.
4. To determine value of Planck’s constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the absorption lines in the rotational spectrum of Iodine vapour.
7. To study the diffraction patterns of single and double slits using laser and measure its intensity variation using Photosensor & compare with incoherent source – Na.
8. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
9. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
10. To setup the Millikan oil drop apparatus and determine the charge of an electron.

**Reference Books:**
- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.

**GE: MATHEMATICAL PHYSICS**

(Credits: Theory-04, Practicals-02)

**Theory: 60 Lectures**

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


Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral). (4 Lectures)

Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. (10 Lectures)


Reference Books:
- An Introduction to Ordinary Differential Equations, E.A Coddington, 1961, PHI Learning

GE LAB: MATHEMATICL PHYSICS
60 Lectures

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

- The course will consist of lectures (both theory and practical) in the Lab
- Evaluation done on the basis of formulating the problem
- Aim at teaching students to construct the computational problem to be solved

<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, Binary search</td>
</tr>
<tr>
<td>Random number generation</td>
<td>Area of circle, area of square, volume of sphere, value of 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= tanα; I = Ie[(Sinα)/α]2 in optics</td>
</tr>
<tr>
<td>Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation</td>
<td>Evaluation of trigonometric functions e.g. sin θ, cos θ, tan θ, etc.</td>
</tr>
</tbody>
</table>
Also attempt the some problems on differential equations like:

1. Solve the coupled first order differential equations

\[ \frac{dx}{dt} = y + x - \frac{x^2}{3}, \quad \frac{dy}{dt} = -x, \]

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 \( 0 \leq t \leq 15 \).

2. The ordinary differential equation describing the motion of a pendulum is

\[ \theta'' = -\sin(\theta) \]

The pendulum is released from rest at an angular displacement \( \alpha \) i.e. \( \theta(0) = \alpha, \theta'(0) = 0 \). Use the RK4 method to 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 in the small \( \theta \) (\( \sin(\theta) \approx \theta \)).

3. Solve the differential equation:

\[ x^2 \frac{d^2 y}{dx^2} - 4x(1 + x) \frac{dy}{dx} + 2(1 + x)y = x^3 \]

with the boundary conditions:

at \( x = 1 \), \( y = (1/2)e^2 \), \( \frac{dy}{dx} = -(3/2)e^2 - 0.5 \), in the range \( 1 \leq x \leq 3 \). Plot \( y \) and \( \frac{dy}{dx} \) against \( x \) in the given range. Both should appear on the same graph.

**Referenced Books:**
- An Introduction to computational Physics, T. Pang, 2nd Edn., 2006, Cambridge Univ. Press

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**GE: SOLID STATE PHYSICS**
*(Credits: Theory-04, Practicals-02)*

**Theory: 60 Lectures**

Prerequisites: Knowledge of “Elements of Modern Physics”


Reference Books:
- Introduction to Solid State Physics, Charles Kittel, 8th Ed., 2004, Wiley India Pvt. Ltd.
- Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India

GE LAB: SOLID STATE PHYSICS
60 Lectures
1. Measurement of susceptibility of paramagnetic solution (Quinck’s Tube Method)
2. To measure the Magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the Dielectric Constant of a dielectric Materials with frequency
5. To 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 study the BH curve of iron using a Solenoid and determine the energy loss.
9. To measure the resistivity of a semiconductor (Ge) crystal with temperature by four-probe method (room temperature to 150 °C) and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.

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

GE: QUANTUM MECHANICS
(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures
Prerequisites: Knowledge of (1) “Mathematical Physics” and (2) “Elements of Modern Physics”


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 the spread of Gaussian wavepacket 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. (12 Lectures)

**Quantum theory of hydrogen-like atoms**: time independent Schrödinger equation in spherical polar coordinates; separation of variables for the second order partial differential equation; angular momentum operator and quantum numbers; Radial wavefunctions from Frobenius method; Orbital angular momentum quantum numbers l and m; s, p, d,.. shells (idea only) (10 Lectures)


**Atoms in External Magnetic Fields**: Normal and Anomalous Zeeman Effect. (4 Lectures)


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

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

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**GE LAB: QUANTUM MECHANICS**

60 Lectures

Use C/C++/Scilab for solving the following problems based on Quantum Mechanics like

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

\[
\frac{d^2y}{dr^2} = A(r)u(r), \quad A(r) = \frac{2m}{\hbar^2} [V(r) - E] \quad \text{where} \quad V(r) = -\frac{e^2}{r}
\]
Here, $m$ is the reduced mass of electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Note that the ground state energy of 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 Schrödinger equation for an atom:
\[
\frac{d^2y}{dr^2} = A(r)u(r), \quad A(r) = \frac{2m}{\hbar^2} [V(r) - E]
\]
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
\[
V(r) = -\frac{e^2}{r} e^{-r/a}
\]
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 $\hbar c = 1973$ (eVÅ). 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 $m$:
\[
\frac{d^2y}{dr^2} = A(r)u(r), \quad A(r) = \frac{2m}{\hbar^2} [V(r) - E]
\]
For the anharmonic oscillator potential
\[
V(r) = \frac{1}{2} kr^2 + \frac{1}{3} br^3
\]
for the ground state energy (in MeV) of the 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, $\hbar c = 197.3$ MeV fm. The ground state energy I expected to lie between 90 and 110 MeV for all three cases.

4. Solve the s-wave radial Schrödinger equation for the vibrations of hydrogen molecule:
\[
\frac{d^2y}{dr^2} = A(r)u(r), \quad A(r) = \frac{2\mu}{\hbar^2} [V(r) - E]
\]
Where $\mu$ is the reduced mass of the two-atom system for the Morse potential
\[
V(r) = D(e^{-2ar'} - e^{-ar'}), \quad r' = \frac{r - r_o}{r_o}
\]
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

Some 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 study the quantum tunnelling effect with solid state device, e.g. tunnelling current in backward diode or tunnel diode.
Reference Books:
- Elementary Numerical Analysis, K.E. Atkinson, 3rd Ed. 2007, Wiley India Edition
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.

GE: EMBEDDED SYSTEM: INTRODUCTION TO MICROCONTROLLERS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Embedded system introduction: Introduction to embedded systems and general purpose computer systems, architecture of embedded system, classifications, applications and purpose of embedded systems, challenges and design issues in embedded systems, operational and non-operational quality attributes of embedded systems, elemental description of embedded processors and microcontrollers.
(6 Lectures)

Review of microprocessors: Organization of Microprocessor based system, 8085µp pin diagram and architecture, concept of data bus and address bus, 8085 programming model, instruction classification, subroutines, stacks and its implementation, delay subroutines, hardware and software interrupts.
(4 Lectures)

8051 microcontroller: Introduction and block diagram of 8051 microcontroller, architecture of 8051, overview of 8051 family, 8051 assembly language programming, Program Counter and ROM memory map, Data types and directives, Flag bits and Program Status Word (PSW) register, Jump, loop and call instructions.
(12 Lectures)

(4 Lectures)

Programming of 8051: 8051 addressing modes and accessing memory using various addressing modes, assembly language instructions using each addressing mode, arithmetic & logic instructions, 8051 programming in C:- for time delay and I/O operations and manipulation, for arithmetic & logic operations, for ASCII and BCD conversions.
(12 Lectures)

Timer & counter programming: Programming 8051 timers, counter programming.
(3 Lectures)
Serial port programming with and without interrupt: Introduction to 8051 interrupts, programming timer interrupts, programming external hardware interrupts and serial communication interrupt, interrupt priority in the 8051. (6 Lectures)

Interfacing 8051 microcontroller to peripherals: Parallel and serial ADC, DAC interfacing, LCD interfacing. (2 Lectures)

Programming Embedded Systems: Structure of embedded program, infinite loop, compiling, linking and locating, downloading and debugging. (3 Lectures)

Embedded system design and development: Embedded system development environment, file types generated after cross compilation, disassembler/ decompiler, simulator, emulator and debugging, embedded product development life-cycle, trends in embedded industry. (8 Lectures)

Reference Books:
- Embedded microcomputer system: Real time interfacing, J.W.Valvano, 2000, Brooks/Cole
- Embedded Microcomputer systems: Real time interfacing, J.W. Valvano 2011, Cengage Learning

PRACTICALS- DSE LAB: EMBEDDED SYSTEM: INTRODUCTION TO MICROCONTROLLERS
60 Lectures

Following experiments using 8051:
1. To find that the given numbers is prime or not.
2. To find the factorial of a number.
3. Write a program to make the two numbers equal by increasing the smallest number and decreasing the largest number.
4. Use one of the four ports of 8051 for O/P interfaced to eight LED’s. Simulate binary counter (8 bit) on LED’s.
5. Program to glow the first four LEDs then next four using TIMER application.
6. Program to rotate the contents of the accumulator first right and then left.
7. Program to run a countdown from 9-0 in the seven segment LED display.
8. To interface seven segment LED display with 8051 microcontroller and display ‘HELP’ in the seven segment LED display.
9. To toggle ‘1234’ as ‘1324’ in the seven segment LED display.
10. Interface stepper motor with 8051 and write a program to move the motor through a given angle in clock wise or counter clockwise direction.
11. Application of embedded systems: Temperature measurement, some information on LCD display, interfacing a keyboard.
Reference Books:
- Embedded Microcomputer systems: Real time interfacing, J.W. Valvano 2011, Cengage Learning

GE: Nuclear and Particle Physics
(Credits: Theory-05, Tutorials-01)

Theory: 75 Lectures
Prerequisites: Knowledge of “Elements of Modern Physics”

General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states. (10 Lectures)

Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force. (12 Lectures)

Radioactivity decay: (a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) β-decay: energy kinematics for β-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. (9 Lectures)

Nuclear Reactions: Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct reaction, resonance reaction, Coulomb scattering(Rutherford scattering). (8 Lectures)

Nuclear Astrophysics: Early universe, primordial nucleosynthesis (particle nuclear interactions), stellar nucleosynthesis, concept of gamow window, heavy element production: r- and s- process path. (5 Lectures)

Interaction of Nuclear Radiation with matter: Energy loss due to ionization (Bethe- Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter. (6 Lectures)
**Detector for Nuclear Radiations:** Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector. (6 Lectures)

**Particle Accelerators:** Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons. (5 Lectures)

**Particle physics:** Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, color quantum number and gluons. (14 Lectures)

**Reference Books:**
- Introductory nuclear Physics by Kenneth S.Krane (Wiley India Pvt. Ltd., 2008).
- Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
- Quarks and Leptons, F. Halzen and A.D.Martin, Wiley India, New Delhi
- Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).

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