CHOICE BASED CREDIT SYSTEM

B. SC. HONOURS WITH PHYSICS
Preamble
B. Sc. (Honours) in Physics

Physics is the most basic of sciences. It seeks to understand natural phenomena in a quantitative manner, and to answer some of the oldest and deepest questions ever asked by human beings: What are things made of? Is there a limit to the smallest things that we can think of? Did the world have a beginning? Will it have an end? At the same time, it provides the base of much of the technology that we take for granted in the 21\textsuperscript{st} century: computers, artificial satellites, mobile phones, TV, microwave ovens... Indeed, it will not be an exaggeration to say that modern human life is shaped by technologies that are largely based on a foundation of physics.

Since the discipline of physics has existed for three hundred years, its ‘core’ body of knowledge is larger than that of many other branches of learning. It was, therefore, difficult to fit this knowledge into 14 core courses. Naturally, we would aim to include as much of basic physics as possible, while introducing the student to the applied aspects of physics. We also need to keep in view the role of physics as a training ground for the mind. Not all students who complete B.Sc. (Hons.) in Physics will go on to become professional physicists. Nevertheless, the study of physics is likely to make them good at logical thinking, quantitative argumentation, etc. Finally, we need to remember that this is an era of interdisciplinary studies. The physics student will benefit by the study of fields that overlap with other domains of knowledge. The syllabus presented here represents an attempt to balance all these requirements.

Finally, a word on the Generic Electives to be chosen by physics students. They are, of course, free to exercise their choice in any way that they see fit. However, for those who wish to pursue higher studies in Physics, it is recommended that they take at two courses in Mathematics and two courses in Chemistry.
# Course Structure (Physics-Major)

Details of courses under B.Sc. (Honours)

<table>
<thead>
<tr>
<th>Course</th>
<th>*Credits</th>
<th>Theory + Practical</th>
<th>Theory + Tutorial</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Core Course (14 Papers)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Core Course Practical / Tutorial* (14 Papers)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II. Elective Course (8 Papers)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A.1. Discipline Specific Elective (4 Papers)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A.2. Discipline Specific Elective Practical / Tutorial* (4 Papers)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.1. Generic Elective / Interdisciplinary (4 Papers)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>B.2. Generic Elective Practical / Tutorial* (4 Papers)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optional Dissertation or project work in place of one Discipline Specific Elective paper (6 credits) in 6th Semester</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III. Ability Enhancement Courses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Ability Enhancement Compulsory</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2 Papers of 2 credit each)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Science</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English/MIL Communication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Ability Enhancement Elective (Skill Based) (Minimum 2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2 Papers of 2 credit each)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total credit</td>
<td>140</td>
<td>140</td>
<td></td>
</tr>
</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. The size of group for practical papers is recommended to be maximum of 12 to 15 students.
## PROPOSED SCHEME FOR CHOICE BASED CREDIT SYSTEM IN
### B. Sc. Honours (Physics)

<table>
<thead>
<tr>
<th>SEMESTER</th>
<th>COURSE OPTED</th>
<th>COURSE NAME</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Ability Enhancement Compulsory Course-I</td>
<td>English/MIL communications/ Environmental Science</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Core course-I</td>
<td>Mathematical Physics-I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Core Course-I Practical/Tutorial*</td>
<td>Mathematical Physics-I Lab</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Core course-II</td>
<td>Mechanics</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Core Course-II Practical/Tutorial*</td>
<td>Mechanics Lab</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Generic Elective -I</td>
<td>GE-1</td>
<td>4/5</td>
</tr>
<tr>
<td></td>
<td>Generic Elective -I Practical/Tutorial*</td>
<td></td>
<td>2/1</td>
</tr>
<tr>
<td>II</td>
<td>Ability Enhancement Compulsory Course-II</td>
<td>English/MIL communications/ Environmental Science</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Core course-III</td>
<td>Electricity and Magnetism</td>
<td>4</td>
</tr>
<tr>
<td>Course Level</td>
<td>Course Code</td>
<td>Course Title</td>
<td>Course Code</td>
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</tr>
<tr>
<td>III</td>
<td>Core course-IV</td>
<td>Waves and Optics</td>
<td>4</td>
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<tr>
<td>III</td>
<td>Core Course-IV Practical/Tutorial*</td>
<td>Waves and Optics Lab</td>
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<tr>
<td>III</td>
<td>Generic Elective-2</td>
<td>GE-2</td>
<td>4/5</td>
</tr>
<tr>
<td>III</td>
<td>Generic Elective-2 Practical/Tutorial*</td>
<td></td>
<td>2/1</td>
</tr>
<tr>
<td>III</td>
<td>Core course-V</td>
<td>Mathematical Physics-II</td>
<td>4</td>
</tr>
<tr>
<td>III</td>
<td>Core Course-V Practical/Tutorial*</td>
<td>Mathematical Physics-II Lab</td>
<td>2</td>
</tr>
<tr>
<td>III</td>
<td>Core course-VI</td>
<td>Thermal Physics</td>
<td>4</td>
</tr>
<tr>
<td>III</td>
<td>Core Course-VI Practical/Tutorial*</td>
<td>Thermal Physics Lab</td>
<td>2</td>
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<tr>
<td>III</td>
<td>Core course-VII</td>
<td>Digital Systems and Applications</td>
<td>4</td>
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<tr>
<td>III</td>
<td>Core Course-VII Practical/Tutorial*</td>
<td>Digital Systems &amp; Applications Lab</td>
<td>2</td>
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<tr>
<td>III</td>
<td>Skill Enhancement Course-1</td>
<td>SEC-1</td>
<td>2</td>
</tr>
<tr>
<td>III</td>
<td>Generic Elective-3</td>
<td>GE-3</td>
<td>4/5</td>
</tr>
<tr>
<td>III</td>
<td>Generic Elective-3 Practical/Tutorial*</td>
<td></td>
<td>2/1</td>
</tr>
<tr>
<td>IV</td>
<td>Core course-VIII</td>
<td>Mathematical Physics III</td>
<td>4</td>
</tr>
<tr>
<td>IV</td>
<td>Course-VIII Practical/Tutorial*</td>
<td>Mathematical Physics-III Lab</td>
<td>2</td>
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<tr>
<td>IV</td>
<td>Core course-IX</td>
<td>Elements of Modern Physics</td>
<td>4</td>
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<tr>
<td>IV</td>
<td>Core course-X</td>
<td>Elements of Modern Physics Lab</td>
<td>2</td>
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<tr>
<td>IV</td>
<td>Core course-X</td>
<td>Analog Systems and Applications</td>
<td>4</td>
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<tr>
<td>IV</td>
<td>Core course-X</td>
<td>Analog Systems &amp; Applications Lab</td>
<td>2</td>
</tr>
<tr>
<td>IV</td>
<td>Skill Enhancement Course-2</td>
<td>SEC-2</td>
<td>2</td>
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<tr>
<td>IV</td>
<td>Generic Elective-4</td>
<td>GE-4</td>
<td>4/5</td>
</tr>
<tr>
<td>IV</td>
<td>Generic Elective-4 Practical/Tutorial*</td>
<td></td>
<td>2/1</td>
</tr>
<tr>
<td>V</td>
<td>Core course-XI</td>
<td>Quantum Mechanics &amp; Applications</td>
<td>4</td>
</tr>
<tr>
<td>V</td>
<td>Core Course-XI Practical/Tutorial*</td>
<td>Quantum Mechanics Lab</td>
<td>2</td>
</tr>
<tr>
<td>V</td>
<td>Core course-XII</td>
<td>Solid State Physics</td>
<td>4</td>
</tr>
<tr>
<td>V</td>
<td>Core Course-XII Practical/Tutorial*</td>
<td>Solid State Physics Lab</td>
<td>2</td>
</tr>
<tr>
<td>V</td>
<td>Discipline Specific Elective-1</td>
<td>DSE-1</td>
<td>4</td>
</tr>
<tr>
<td>V</td>
<td>Discipline Specific Elective-1 Practical/Tutorial*</td>
<td>DSE-1 Lab</td>
<td>2</td>
</tr>
<tr>
<td>V</td>
<td>Discipline Specific Elective-2</td>
<td>DSE-2</td>
<td>4</td>
</tr>
<tr>
<td>V</td>
<td>Discipline Specific Elective-2 Practical/Tutorial*</td>
<td>DSE-2 Lab</td>
<td>2</td>
</tr>
<tr>
<td>VI</td>
<td>Core course-XIII</td>
<td>Electro-magnetic Theory</td>
<td>4</td>
</tr>
<tr>
<td>VI</td>
<td>Core Course-XIII Practical/Tutorial*</td>
<td>Electro-magnetic Theory Lab</td>
<td>2</td>
</tr>
<tr>
<td>VI</td>
<td>Core course-XIV</td>
<td>Statistical Mechanics</td>
<td>4</td>
</tr>
<tr>
<td>VI</td>
<td>Core Course-XIV Practical/Tutorial*</td>
<td>Statistical Mechanics Lab</td>
<td>2</td>
</tr>
<tr>
<td>VI</td>
<td>Discipline Specific Elective-3</td>
<td>DSE-3</td>
<td>4</td>
</tr>
<tr>
<td>VI</td>
<td>Discipline Specific Elective-3 Practical/Tutorial*</td>
<td>DSE-3 Lab</td>
<td>2</td>
</tr>
<tr>
<td>VI</td>
<td>Discipline Specific Elective-4</td>
<td>DSE-4</td>
<td>4</td>
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<tr>
<td>VI</td>
<td>Discipline Specific Elective-4 Practical/Tutorial*</td>
<td>DSE-4 Lab</td>
<td>2</td>
</tr>
</tbody>
</table>
Wherever there is a practical there will be no tutorial and vice-versa. The size of group for practical papers is recommended to be maximum of 12 to 15 students.

**B.Sc. (Hons) Physics**

**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) - DSE 1-4**
(4 papers to be selected: 02 each for Odd semester and Even semester as listed below)

**Odd semester:**
1. Experimental Techniques (4) + Lab (4)
2. Advanced Mathematical Physics (4) + Lab (4) or Linear Algebra and Tensor analysis (5) + Tutorial (1)
3. Embedded systems- Introduction to Microcontroller (4) + Lab (4)
4. Nuclear and Particle Physics (5) + Tutorial (1)
5. Physics of Devices and Communication (4) + Lab (4)
6. Astronomy and Astrophysics (5) + Tutorial (1)
7. Atmospheric Physics (4) + Lab (4)
8. Biological physics (5) + Tutorial (1)

**Even Semester:**
9. Advanced Mathematical Physics-II (5) + Tutorial (1)
10. Communication System (4) + Lab (1)
11. Applied Dynamics (4) + Lab (4)
12. Verilog and FPGA based system design (4) + Lab (4)
13. Classical Dynamics (5) + Tutorial (1)
14. Digital Signal processing (4) + Lab (4)
15. Nano Materials and Applications(4) + Lab (4)
16. Physics of the Earth (5) + Tutorial (1)
17. Medical Physics (4) + Lab (4)
18. Advanced Quantum Mechanics (5) + Tutorial (1)
19. Dissertation

**Skill Enhancement Courses (02 to 04 papers) (Credit: 02 each)- SEC1 to SEC4**
1. Physics Workshop Skills
2. Computational Physics Skills
3. Electrical circuits and Network Skills
4. Basic Instrumentation Skills
5. Renewable Energy and Energy harvesting
6. Engineering Design and Prototyping
7. Radiation Safety
8. Applied Optics
9. Weather Forecasting
10. Introduction to Physical Computing
11. Numerical Analysis

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

**Odd Semesters (1\textsuperscript{st} and 3\textsuperscript{rd}semesters)**
1. Electricity and Magnetism (4) + Lab (4)
2. Mathematical Physics(4) + Lab (4)
3. Digital, Analog and Instrumentation(4) + Lab (4)
4. Applied Dynamics (4) + Lab (4)
5. Medical Physics (4) + Lab (4)
6. Waves and Optics (4) + Lab (4)
7. Quantum Mechanics (4) + Lab (4)*
8. Communication System (4) + Lab (4)*
9. Verilog and FPGA based system design (4) + Lab (4)*
10. Nano Materials and Applications(4) + Lab (4)*

*Not offered in 1\textsuperscript{st} semester.

**Even semesters (2\textsuperscript{nd} and 4\textsuperscript{th} semesters)**
11. Mechanics (4) + Lab (4)
12. Elements of Modern Physics (4) + Lab (4)
13. Solid State Physics (4) + Lab (4)
14. Embedded System: Introduction to microcontroller(4) + Lab (4)
15. Biological physics (5) + Tutorials (1)
16. Thermal Physics (4) + Lab (4)
17. Digital Signal processing (4 ) + Lab (4)
18. Nuclear and Particle Physics (5) + Tut (1)**
19. Astronomy and Astrophysics (5) + Tutorials (1)**
20. Atmospheric Physics (4) + Lab (4)**
21. Physics of the Earth (5) + Tutorials (1)**
**Not offered in 2nd semester.
CORE COURSE (HONOURS IN PHYSICS)

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Semester I

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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: Plotting of functions. Approximation: Taylor and binomial series (statements only). First Order Differential equations (variable separable, homogeneous, non-homogeneous), exact and inexact differential equations and Integrating Factor.

(6 Lectures)


(15 Lectures)


(6 Lectures)


(10 Lectures)


(16 Lectures)

Orthogonal Curvilinear Coordinates:

(7 Lectures)

Reference Books:
- An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
- Mathematical Physics, Goswami, 1st edition, Cengage Learning

PHYSICS LAB- CI LAB:

60 Periods

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 physics problems
- The course will consist of lectures (both theory and practical) in the Lab
- Evaluation to be 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
- At least 12 programs must be attempted from the following

<table>
<thead>
<tr>
<th>Topics</th>
<th>Descriptions 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 and overflow - emphasize the importance of making equations in terms of dimensionless variables, Iterative methods</td>
</tr>
<tr>
<td>Algorithms and Flow charts</td>
<td>Purpose, symbols and description</td>
</tr>
</tbody>
</table>
| Introduction to C++           | Introduction to Programming: Algorithms: Sequence, Selection and Repetition, Structured programming, basic idea of Compilers. Data Types, Enumerated Data, Conversion & casting, constants and variables, Mathematical, Relational, Logical and Bitwise Operators. Precedence of Operators, Expressions and Statements, Scope and Visibility of Data, block, Local and Global variables, Auto, static and External variables. Programs:  
  - To calculate area of a rectangle  
  - To check size of variables in bytes (Use of sizeof() Operator) |
| C++ Control 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, nested loops, break and continue statements  
Programs:  
- To find roots of a quadratic equation if...else  
And if...else if  
- To find largest of three numbers  
- To check whether a number is prime or not  
- To list Prime numbers up to 1000 |
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Random Number generator</td>
</tr>
<tr>
<td>Arrays and Functions</td>
</tr>
</tbody>
</table>
| Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods | Solution of linear and quadratic equation, solving  
\[ \alpha = \tan \alpha; \quad I = I_0 \left( \frac{\sin \alpha}{\alpha} \right)^2 \] in optics, |
| Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation | Evaluation of trigonometric functions e.g. \( \sin \theta, \cos \theta, \tan \theta \) etc |
| Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method | Given Position with equidistant time data calculate velocity and acceleration and vice versa. Find the area of BH Hysteresis loop |
| Solution of Ordinary Differential Equations (ODE) | First order differential equation  
- Radioactive decay  
- Current in RC, LC circuits with DC source  
- Newton’s law of cooling  
- Classical equations of motion  
Attempt following problems using RK 4 order method:  
- Solve the coupled differential equations  
\[ \frac{dx}{dt} = y + x - \frac{x^3}{3}; \quad \frac{dy}{dx} = -x \] for four initial conditions |
\[
x(0) = 0, \quad y(0) = -1, -2, -3, -4.
\]
Plot \( x \) vs \( y \) for each of the four initial conditions on the same screen for \( 0 \leq t \leq 15 \)

**Referred Books:**

**PHYSICS-C II: MECHANICS**
(Credits: Theory-04, Practicals-02)

**Theory: 60 Lectures**

*This course begins with the review of Newton’s Laws of Motion and ends with the Fictitious Forces and Special Theory of Relativity. Students will also appreciate the Collisions in CM Frame, Gravitation, Rotational Motion and Oscillations. The emphasis of this course is to enhance the understanding of the basics of mechanics. By the end of this course, students should be able to solve the seen or unseen problems/numericals in mechanics.*


(7 Lectures)


(5 Lectures)

**Collisions:** Elastic (1-D and 2-D) and inelastic collisions. Centre of Mass and Laboratory frames.

(4 Lectures)

cylindrical and spherical). Kinetic energy of rotation. Motion involving both translation and rotation. (10 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. (2 Lectures)

**Motion of a particle under a central force field:** Two-body problem, its reduction to one-body problem and its solution. Reduction of angular momentum, kinetic energy and total energy. The energy equation and energy diagram. Kepler’s Laws. Satellite in circular orbit, Geosynchronous orbits. (7 Lectures)

**Oscillations:** Idea of SHM. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Compound pendulum. Damped oscillation. Forced oscillations: Transient and steady states, sharpness of resonance and Quality Factor. (6 Lectures)

**Non-Inertial Systems:** Reference frames, Galilean transformations, Galilean invariance, Inertial and Non-inertial frames and fictitious forces. Uniformly rotating frame. Centrifugal force. Coriolis force and its applications. (5 Lectures)


**Reference Books:**
- Mechanics, DS Mathur, PS Hemne, 2012, S. Chand
- University Physics, FW Sears, MW Zemansky & HD Young 13/e, 1986, AddisonWesley
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole

**PHYSICS LAB-C II LAB**

**60 Periods**

*At least 06 experiments from the following*
1. Measurements of length (or diameter) using Vernier calliper, 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 the spring and calculate (a) Spring constant and, (b) g.

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

Electricity and Magnetism is one of the core courses in Physics curriculum. The course covers static and dynamic electric and magnetic field, and the principles of electromagnetic induction. It also includes analysis of electrical circuits and introduction of network theorems. By the end of the course student should be able to appreciate Maxwell’s equations and analyze electrical circuits using network theorems.

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 \( \mathbf{D} \). Relations between \( \mathbf{E} \), \( \mathbf{P} \) and \( \mathbf{D} \). Gauss’ Law in dielectrics. (8 Lectures)

**Magnetic Field:** Magnetic force between current elements and definition of Magnetic Field \( \mathbf{B} \). Biot-Savart’s Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere’s Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of \( \mathbf{B} \): curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field. (9 Lectures)

**Magnetic Properties of Matter:** Magnetization vector \( \mathbf{M} \). Magnetic Intensity \( \mathbf{H} \). Magnetic Susceptibility and permeability. Relation between \( \mathbf{B, H, M} \). Ferromagnetism. \( \mathbf{B-H} \) 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. (5 Lectures)


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

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PHYSICS LAB-C III LAB

60 Periods

The laboratory content compliments the theoretical knowledge of Electricity and Magnetism and hence, gives hands-on experience. Also, it provides the observational understanding of the subject. It enhances the qualitative and quantitative skills of the students.

At least 6 experiments from the following

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

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

This is one of the core course in Physics curriculum that begins with explaining ideas of superposition of harmonic oscillations leading to physics of travelling and standing waves. The course also provides an in depth understanding of wave phenomena of light, namely, interference and diffraction with emphasis on practical applications of the same.

Superposition of Collinear Harmonic oscillations: Simple harmonic motion (SHM). 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. (6 Lectures)

Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequencies 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. (6 Lectures)
Diffraction:


Reference Books

PHYSICS LAB - C IV LAB
60 Periods
The laboratory content compliments the theoretical knowledge of Waves and Optics and gives hands-on experience. Also, it provides the observational understanding of the subject. It enhances the qualitative and quantitative skills of the students.

At least 6 experiments from the following
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

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Semester III

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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. (4 Lectures)

Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Laplace’s Equation in problems of rectangular geometry. Solution
of wave equation for vibrational modes of a stretched string, rectangular and circular membranes. Solution of 1D heat flow equation (equation not to be derived).

(15 Lectures)

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

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PHYSICS LAB-C V LAB

60 Periods

The aim of this Lab is to use the computational methods to solve physical problems. The course will consist of lectures (both theory and practical) in the Computer Lab. Evaluation done not on the basis of programming but on the basis of formulating the problem. At least two programs must be attempted from each programming section.

<table>
<thead>
<tr>
<th>Topics</th>
<th>Description with Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to Numerical</td>
<td>Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window,</td>
</tr>
<tr>
<td>computation software Scilab</td>
<td>Figure window, Edit window, Variables and arrays, Initialising variables in Scilab, Multidimensional arrays, Sub-array, 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, Branching Statements and program design, Relational and logical operators, the while loop, for loop, details of loop operations, break and continue statements, nested loops, logical arrays and vectorization. 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 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.</td>
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<tr>
<td>Curve fitting, Least square fit,</td>
<td>Ohms law calculate R, Hooke’s law, Calculate spring constant,</td>
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<tr>
<td>Goodness of fit, standard deviation using Scilab</td>
<td>Given Bessel’s function at N points find its value at an intermediate point.</td>
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<tr>
<td>Solution of Linear system of</td>
<td>Solution of mesh equations of electric circuits (3 meshes)</td>
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<td>equations by Gauss elimination</td>
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<tr>
<td>Method</td>
<td>Description</td>
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<tr>
<td>Diagonalisation of matrices, Inverse of a matrix, Eigen vectors, eigen-values problems</td>
<td>Solution of coupled spring mass systems (3 masses)</td>
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<tr>
<td>Generation of Special functions using User defined functions in Scilab</td>
<td>Generating and plotting Legendre Polynomials Generating and plotting Bessel function</td>
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<tr>
<td>Solution of ODE</td>
<td>First order differential equation:</td>
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<td>First order Differential equation</td>
<td>• Radioactive decay</td>
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<tr>
<td>Euler, modified Euler and Runge-Kutta (RK) second and Fourth</td>
<td>• Current in RC, LC circuits with DC source</td>
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<td>order methods</td>
<td>• Newton’s law of cooling</td>
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<tr>
<td>Second order differential equation</td>
<td>• Classical equations of motion</td>
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<tr>
<td>Fixed difference method</td>
<td>Second order Differential Equation:</td>
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<tr>
<td>Partial differential equations</td>
<td>• Harmonic oscillator (no friction)</td>
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<td>• Damped Harmonic oscillator</td>
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<td>o Oscillatory</td>
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<td>• Forced Harmonic oscillator</td>
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<td>o Transient</td>
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<td>o Steady state solution</td>
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<td></td>
<td>• Apply above to LCR circuits also</td>
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<td></td>
<td>• Solve $x^2 \frac{d^2 y}{dx^2} - 4x(1 + x) \frac{dy}{dx} + 2(1 + x)y = x^3$</td>
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<td>with the boundary conditions at</td>
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<td>$x = 1, y = \frac{1}{2} e^2, \frac{dy}{dx} = -\frac{3}{2} e^2 - 0.5$,</td>
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<td>in the range $1 \leq x \leq 3$. Plot $y$ and $\frac{dy}{dx}$ against $x$</td>
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<td>in the given range on the same graph.</td>
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<tr>
<td>Partial Differential Equation:</td>
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<td>Wave equation</td>
<td>• Wave equation</td>
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<td>• Heat equation</td>
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<td>• Poisson equation</td>
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<td>• Laplace equation</td>
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<tr>
<td>Using Scicos/xcos</td>
<td>• Generating sine wave, square wave, sawtooth wave</td>
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<td></td>
<td>• Solution of harmonic oscillator</td>
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<td></td>
<td>• Study of heat phenomenon</td>
</tr>
<tr>
<td></td>
<td>• Phase space plots</td>
</tr>
</tbody>
</table>

**Reference Books:**
- Getting started with Matlab, Rudra Pratap, 2010, Oxford University Press.
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific
PHYSICS-C VI: THERMAL PHYSICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

This course work deal with the relationship between the macroscopic properties of the physical system in equilibrium. The primary goal is to understand the fundamental laws of thermodynamics and it’s applications to various thermo dynamical systems and processes. In addition, it will also give exposure to students about the Kinetic theory of gases, transport phenomenon involved in ideal gases, phase transitions and behavior of real gases.

(Include related problems for each topic)

Introduction to Thermodynamics


Maxwell’s Thermodynamic Relations: Derivation of Maxwell’s thermodynamic Relations and their applications, Maxwell’s Relations:(1) Clausius Clapeyron equation,
Value of $C_p - C_V$, Tds Equations, Energy equations. (7 Lectures)

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 Periods
At least 5 experiments from the following
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 using a null method. And also calibrate the
Thermocouple in a specified temperature range.

7. To calibrate a thermocouple to measure temperature in a specified Range using Op-Amp difference amplifier and to determine Neutral Temperature.

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 VII: DIGITAL SYSTEMS AND APPLICATIONS
(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

This is one of the core papers in physics curriculum which introduces the concept of Boolean algebra and the basic digital electronics. In this course, students will be able to understand the working principle of CRO, Data processing circuits, Arithmetic Circuits, sequential circuits like registers, counters etc. based on flip flops. In addition, students will get an overview of microprocessor architecture and programming.


Digital Circuits: Difference between Analog and Digital Circuits. Examples of linear and digital ICs, Binary Numbers. Decimal to Binary and Binary to Decimal Conversion, BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers. (6 Lectures)


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


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

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

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


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

Reference Books:

PHYSICS PRACTICAL-C VII LAB
60 Periods
At least 06 experiments each from section A and Section B
Section-A: Digital Circuits Hardware design/Verilog Design

1. To design a combinational logic system for a specified Truth Table.
   (b) To convert Boolean expression into logic circuit & design it using logic gate ICs.
(c) To minimize a given logic circuit.

2. Half Adder, Full Adder and 4-bit binary Adder.

3. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.

4. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.

5. To build JK Master-slave flip-flop using Flip-Flop ICs.

6. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.

7. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.

8. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO and to design an astable multivibrator of given specifications using 555 Timer.

9. To design a monostable multivibrator of given specifications using 555 Timer.

Section-B: Programs using 8085 Microprocessor:

1. Addition and subtraction of numbers using direct addressing mode

2. Addition and subtraction of numbers using indirect addressing mode

3. Multiplication by repeated addition.

4. Division by repeated subtraction.

5. Handling of 16-bit Numbers.

6. Use of CALL and RETURN Instruction.

7. Block data handling.

8. Parity Check

9. Other programs (e.g. using interrupts, etc.).

Reference Books:


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.


Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Coupled differential equations of 1st order. Solution of heat flow along semi infinite bar using Laplace transform. (15 Lectures)

Dirac delta function: Definition and properties. Representation of Dirac delta function as a Fourier Integral. Laplace and Fourier Transform of Dirac delta function. (3 Lectures)

Reference Books:

PHYSICS PRACTICAL-C VIII LAB
60 Periods
C++/C/Scilab based simulations experiments on Mathematical Physics problems like
1. Solve differential equations:
   \[ dy/dx = e^{-x} \] with \( y = 0 \) for \( x = 0 \)
\[
\frac{dy}{dx} + e^{-x}y = x^2 \\
\frac{d^2y}{dt^2} + 2 \frac{dy}{dt} = -y \\
\frac{d^2y}{dt^2} + e^{4\frac{dy}{dt}} = -y
\]

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:

\[
\int_{-1}^{+1} P_n(\overline{m}) P_m(\overline{m}) \, d\overline{m} = \delta_{n,m} \\
\text{Plot } P_n(x), J_0(x) \\
\text{Show recursion relation}
\]

5. 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.

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

7. Calculation of least square fitting manually for a given data set and confirmation of least square fitting of data through computer program.

8. Integral transform: Fast Fourier Transform of \( e^{-x^2} \)

Reference Books:
- Getting started with Matlab, Rudra Pratap, 2010, Oxford University Press.

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PHYSICS-C IX: ELEMENTS OF MODERN PHYSICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures
This course introduces modern development in Physics. Starting from Planck’s law, it develops the idea of probability interpretation and then discusses the formulation of Schrodinger equation. It also introduces basic concepts of nuclear physics.


(12 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 carrier particles and range of an interaction.  

(7 Lectures)

Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; 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.  

(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. Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions).  

(3 Lectures)


(4 Lectures)

Reference Books:
• Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
• Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
• Six Ideas that Shaped Physics:Particle Behave like Waves, T.A.Moore,2003, McGraw Hill

PHYSICS PRACTICAL-C IX LAB
60 Periods
At least 06 experiments from following:
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 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.Praaksh& Ramakrishna, 11th Edn, 2011,Kitab Mahal

PHYSICS-C X: ANALOG SYSTEMS AND APPLICATIONS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures
This is one of the core papers in physics curriculum where students will get to learn about the physics of semiconductor p-n junction and devices such as rectifier diodes, zener diode, photodiode etc. and bipolar junction transistors. Transistor biasing and stabilization circuits are explained. The concept of feedback is discussed in amplifiers and the oscillator circuits are also studied. By the end of the syllabus, students will also have an understanding of operational amplifiers and their applications.


**Two-terminal Devices and their Applications:** (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter, (2) Zener Diode and Voltage Regulation.Principle, structure and characteristics of (1) LED, (2) Photodiode and (3) Solar Cell, Qualitative idea of Schottky diode and Tunnel diode. (7 Lectures)

**Bipolar Junction transistors:** n-p-n and p-n-p Transistors. I-V characteristics of CBand CE Configurations.Active, Cutoff and Saturation Regions. Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. (6 Lectures)


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

**Feedback in Amplifiers:** Positive and Negative Feedback. Effect of 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)

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

Reference Books:
- Microelectronic Devices & Circuits, David A.Bell, 5th Edn.,2015, Oxford University Press

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PHYSICS PRACTICAL-C X LAB

60 Periods

At least 08 experiments from the following:
1. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
2. Study of V-I & power curves of solar cells, and find maximum power point & efficiency.
3. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
4. To study the various biasing configurations of BJT for normal class A operation.
5. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
6. To study the frequency response of voltage gain of a two stage RC-coupled transistor amplifier.
7. To design a Wien bridge oscillator for given frequency using an op-amp.
8. To design a phase shift oscillator of given specifications using BJT.
9. To design a digital to analog converter (DAC) of given specifications.
10. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain
11. (a) To design inverting amplifier using Op-amp(741,351) & study its frequency response
(b) To design non-inverting amplifier using Op-amp (741,351) & study frequency response

12. (a) To add two dc voltages using Op-amp in inverting and non-inverting mode

(b) To study the zero-crossing detector and comparator.


14. To investigate the use of an op-amp as an Integrator.

15. To investigate the use of an op-amp as a Differentiator.

16. To design a circuit to simulate the solution of simultaneous equation and 1st/2nd order differential equation.

Reference Books:

Semester V

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

In continuation with modern physics this course is an application of Schrodinger equation to various quantum mechanical problems. This gives fair idea of formulation of eigenvalues and eigen functions.


(12 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.  

(12 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. (10 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 and first excited states; Orbital angular momentum quantum numbers l and m; s, p, dshells. (10 Lectures)


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

PHYSICS PRACTICAL-C XI LAB

60 Periods

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:

\[
\frac{d^2 y}{dr^2} = A(r)u(r), \quad A(r) = \frac{2m}{\hbar^2} [V(r) - E] \text{ where } V(r) = -\frac{e^2}{r}
\]

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 \( e = 3.795 \text{ (eV}\AA)^{1/2} \), \( \hbar c = 1973 \text{ (eV}\AA) \) and \( m = 0.511\times10^6 \text{ eV}/c^2 \).

2. Solve the s-wave radial Schrödinger equation for an atom:
\[
\frac{d^2 y}{dr^2} = A(r)u(r), \quad A(r) = \frac{2m}{\hbar^2} [V(r) - E]
\]

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 \(e = 3.795 \text{ (eVÅ)}^{1/2}\), \(m = 0.511 \times 10^6 \text{ eV/c}^2\), and \(a = 3 \text{ Å}, 5 \text{ Å}, 7 \text{ Å}\). In these units \(\hbar c = 1973 \text{ (eVÅ)}\). The ground state energy is expected to be above -12 eV in all three cases.

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

\[
\frac{d^2 y}{dr^2} = A(r)u(r), \quad A(r) = \frac{2m}{\hbar^2} [V(r) - E]
\]

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, \(\hbar c = 197.3 \text{ MeV fm}\). The ground state energy is expected to lie between 90 and 110 MeV for all three cases.

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

\[
\frac{d^2 y}{dr^2} = A(r)u(r), \quad A(r) = \frac{2\mu}{\hbar^2} [V(r) - E]
\]

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

\[
V(r) = D \left(e^{-ar'} - e^{-ar'}\right), \quad r' = \frac{r - r_o}{r}
\]

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function. Take: \(m = 940 \times 10^6 \text{eV/C}^2\), \(D = 0.755501 \text{ eV}\), \(\alpha = 1.44\), \(r_o = 0.131349 \text{ Å}\).

Laboratory based experiments (Optional):
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. Quantum efficiency of CCDs

Reference Books:
- Schaum's outline of Programming with C++ J. Hubbard, 2000, McGraw-Hill Publication
- An introduction to computational Physics, T. Pang, 2nd Edn., 2006, Cambridge Univ. Press
- Scilab (A Free Software to Matlab); H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
PHYSICS-C XII: SOLID STATE PHYSICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures
This syllabus gives an introduction to the basic phenomena in Solid State Physics. This aims to provide a general introduction to theoretical and experimental topics in solid state physics. On successful completion of the module students should be able to elucidate the main features of crystal lattices and phonons, understand the elementary lattice dynamics and its influence on the properties of materials, describe the main features of the physics of electrons in solids; explain the dielectric ferroelectric and magnetic properties of solids and understand the basic concept in superconductivity.


Ferroelectric Properties of Materials: Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.

Reference Books:
- Introduction to Solid State Physics, Charles Kittel, 8th Edn., 2004, Wiley India Pvt. Ltd.

PHYSICS PRACTICAL-C XII LAB
60 Periods
At least 06 experiments from the following
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) technique.
6. To determine the refractive index of a dielectric using SPR technique.
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 (up to 150°C) by four-probe method and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.
11. To measure the resistivity of a semiconductor (Ge) with temperature by two-probe method and to determine its band gap.

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

Electromagnetic theory is a core course in B. Sc. (Honours) Physics curriculum. The course covers Maxwell’s equations, propagation of electromagnetic (em) waves in different homogeneous-isotropic as well as anisotropic unbounded and bounded media, production and detection of different types of polarized em waves, general information as waveguides and fibre optics.


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)


**Optical Fibres:** Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres. (3 Lectures)

**Reference Books:**
- Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
- Electromagnetic Field and Waves, P. Lorrain and D. Corson, 2nd Ed., 2003, CBS Publisher.
- Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
- Classical Electrodynamics, J.D. Jackson, 3rd Edn., 2010, Wiley

**PHYSICS PRACTICAL-C XIII LAB**

60 Periods

*The laboratory content compliments the theoretical knowledge of Electromagnetic Theory and gives hands-on experience. Also, it provides the observational understanding of the subject. It enhances the qualitative and quantitative skills of the students.*

At least 06 experiments from the following

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 Boltzmann constant using V-I characteristics of PN junction diode.

13. To find Numerical Aperture of an Optical Fibre.

14. To verify Brewster’s Law and to find the Brewster’s angle.

**Reference Books:**
- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

**PHYSICS-C XIV: STATISTICAL MECHANICS**

*(Credits: Theory-04, Practicals-02)*

**Theory: 60 Lectures**

The Statistical Mechanics deals with the derivation of the macroscopic parameters (internal energy, pressure, specific heat etc.) of a physical system consisting of large number of particles (solid, liquid or gas) from knowledge of the underlying microscopic behavior of atoms and molecules that comprises it. The main objective of this course work is to introduce the techniques of Statistical Mechanics which has applications in various fields including Astrophysics, Semiconductors, Plasma Physics, Bio-Physics, Chemistry and in many other directions.

**Unit I: Classical Statistics**


**Unit II: Bose-Einstein Statistics:**

B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck’s law. *(13 Lectures)*

**Unit III: Fermi-Dirac Statistics:**

Unit IV : Theory of Radiation

Reference Books:
- Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
- An Introduction to Statistical Mechanics & Thermodynamics, R.H.Swendsen, 2012, Oxford Univ. Press
- Statistical Physics , F. Mandl, 2nd Edn., 2003, Wiley
- A treatise on Heat, M. N. Saha and B.N. Srivastava

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PHYSICS PRACTICAL-C XIV LAB
60 Periods
Use C/C++/Scilab/other numerical simulations for solving the problems based on Statistical Mechanics like

1. Computational analysis of the behavior of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:
   a) Study of local number density in the equilibrium state (i) average; (ii) fluctuations
   b) Study of transient behavior of the system (approach to equilibrium)
   c) Relationship of large N and the arrow of time
   d) Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution
   e) Computation and study of mean molecular speed and its dependence on particle mass
   f) Computation of fraction of molecules in an ideal gas having speed near the most probable speed
2. Computation of the partition function $Z(\beta)$ for examples of systems with a finite number of single particle levels (e.g., 2 level, 3 level, etc.) and a finite number of non-interacting particles $N$ under Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics:

   a) Study of how $Z(\beta)$, average energy $\langle E \rangle$, energy fluctuation $\Delta E$, $C_V$, depend upon the temperature, total number of particles $N$ and the spectrum of single particle states.
   
   b) Ratios of occupation numbers of various states for the systems considered above
   
   c) Computation of physical quantities at large and small temperature $T$ and comparison of various statistics at large and small temperature $T$.

3. Plot Planck’s law for Black Body radiation and compare it with Raleigh-Jeans Law at large and small wavelength for a given temperature.

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

5. Plot the following functions with energy at different temperatures

   a) Maxwell-Boltzmann distribution
   
   b) Fermi-Dirac distribution
   
   c) Bose-Einstein distribution

6. Plot the distribution of particles w.r.t. energy ($dN/d\varepsilon$ versus $\varepsilon$) for

   a) Relativistic and non-relativistic bosons both at high and low temperature.
   
   b) Relativistic and non-relativistic fermions both at high and low temperature.

Reference Books:
- ElementaryNumericalAnalysis, K.E.Atkinson, 3rd Ed.n. 2007, WileyIndiaEdition
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer

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PHYSICS-DSE I-IV (ELECTIVES): Select any four paper.
Odd Semester Options (DSE I – II): Select any 02 papers

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

This paper aims to describe the errors in measurement and statistical analysis of data required while performing an experiment. Also, students will learn the working principle, efficiency and applications of transducers & industrial instruments like digital multimeter, RTD, Thermistor, Thermocouples and Semiconductor type temperature sensors.

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. Gaussian 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 with roughing and backing, Mechanical pumps (Rotary and root pumps), Diffusion pump & Turbo Molecular pump, Ion pumps, Pumping speed, throughput, Pressure gauges (Pirani, Penning, ionization, cold cathode). *(16 Lectures)*

**Reference Books:**
- Experimental Methods for Engineers, J.P. Holman, McGraw Hill
- Electronic circuits: Handbook of design & applications, U.Tietze, Ch.Schenk, Springer

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**PRACTICAL- DSE LAB: EXPERIMENTAL TECHNIQUES**

**60 Periods**

*At least 06 experiments each from the following:*

1. Determine output characteristics of a LVDT & measure displacement using LVDT
2. Measurement of
   - (a) Strain using Strain Gauge,
   - (b) level using capacitive transducer.
   - (c) distance using ultrasonic transducer
3. To study the characteristics of a Thermostat and determine its parameters.
4. Calibrate Semiconductor type temperature sensor (AD590, LM35, LM75) and Resistance Temperature Device (RTD).
5. Create vacuum in a small chamber using a mechanical (rotary) pump and measure the chamber pressure using a pressure gauge.
6. 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.
7. To design and study the Sample and Hold Circuit.
8. Design and analyze the Clippers and Clampers circuits using junction diode
9. To plot the frequency response of a microphone.
10. To measure Q of a coil and influence of frequency, using a Q-meter.

**Reference Books:**
Note: Students opting for Advanced mathematical physics-I course as one option in DSE cannot opt for Linear algebra and Tensor analysis as second option.

PHYSICS-DSE: ADVANCED MATHEMATICAL PHYSICS-I
(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.


**Reference Books:**

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**PHYSICS PRACTICAL-DSE LAB: ADVANCED MATHEMATICAL PHYSICS-I LAB**

60 Periods

*Scilab/C++ based simulations experiments based on Mathematical Physics problems like (at least 06 experiments)*

1. Linear algebra:
   - Multiplication of two 3 x 3 matrices.
   - Eigenvalue and eigenvectors of
     \[
     \begin{pmatrix}
     2 & 1 & 1 \\
     1 & 3 & 2 \\
     3 & 1 & 4
     \end{pmatrix}
     \begin{pmatrix}
     1 \\
     +i \\
     -2i
     \end{pmatrix}
     \begin{pmatrix}
     -i \\
     2 \\
     3
     \end{pmatrix}
     \begin{pmatrix}
     3 + 4i \\
     4 \\
     5
     \end{pmatrix}
     \]

2. Orthogonal polynomials as eigenfunctions of Hermitian differential operators.

3. Determination of the principal axes of moment of inertia through diagonalization (Matrix can be generated for a given distribution of discrete masses).


5. Application to solve differential equations for a bound system – Eigen value problem.
6. Application to computer graphics:
Write operators for shear, strain, two dimensional rotational problems, Reflection, Translation etc. Plot old and new coordinates.

Reference Books:

Note: Students opting for Linear algebra and Tensor analysis as one option in DSE cannot opt Advanced mathematical physics-I course as second option.

PHYSICS – DSE: LINEAR ALGEBRA AND TENSOR ANALYSIS
(Credits: Theory -05, Tutorial -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.

Vector Space and Subspace: Binary Operations, Groups, Rings & Fields, Vector Space & Subspace, Examples of Vector Spaces, Euclidean Vector Spaces: Length and Distance in \( \mathbb{R}^n \), Matrix notation for vectors in \( \mathbb{R}^n \), Four Subspaces associated with a Matrix

(8 Lectures)

Basic and Dimension: Linear Dependence and Independence of vectors, Spanning a Space, Basis and Dimensions, Rank and Nullity of a Matrix, Examples from Real Function Space and Polynomial Space, Orthogonal Vectors and Subspaces, Orthogonal Basis, Gram-Schmidt process of generating an Orthonormal Basis

(4 Lectures)


(8 Lectures)

Invertible operators: Identity Transformation, Matrices and Linear Operators, Matrix Representation of a Linear transformation and change of basis, Similarity

(5 Lectures)

Matrices and Matrix Operations: Addition and Multiplication of Matrices, Null Matrices, Diagonal, Scalar and Unit Matrices, Upper Triangular and Lower-Triangular Matrices, Transpose of a Matrix, Symmetric and Skew-Symmetric Matrices, Matrices for Networks, Matrix Multiplication and System of Linear Equations, Augmented Matrix, Echelon Matrices, Gauss Elimination and Gauss-Jordan Elimination, Inverse of a Matrix,


**Geometrical Applications:** Equation of a line, Angle between lines. Projection of a line on another line. Condition for two lines to be coplanar. Foot of the Perpendicular from a Point on a Line, Rotation Tensor (No derivation), Isotropic tensors (definition only), Moment of Inertia tensors. (4 Lectures)

**General Tensors:** Transformation of Co-ordinates, Minkowski Space, Contravariant & Covariant Vectors, Contravariant, Covariant and Mixed Tensors, Kronecker Delta and Permutation Tensors, Algebra of Tensors, Sum, Difference & Product of Two Tensors, Contraction, Quotient Law of Tensors, Symmetric and Anti-symmetric Tensors, Metric Tensor. (10 Lectures)

**Reference Books:**
PHYSICS-DSE: EMBEDDED SYSTEM: INTRODUCTION TO MICROCONTROLLERS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures
This paper gives a review of microprocessor and introduces microcontroller 8051. Here, students will learn about the 8051 I/O port programming, various addressing modes, Timer and counter programming, Serial port programming with and without interrupt and interfacing 8051 microcontroller to peripherals.

Embedded system introduction: Introduction to embedded systems and general purpose computer systems, architecture of embedded system, classifications, applications and purpose of embedded systems. (4 Lectures)

8051 microcontroller: Introduction and block diagram of 8051 microcontroller, architecture of 8051, 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)

Introduction to Arduino: Pin diagram and description of Arduino UNO. Basic programming and applications.

(6 Lectures)

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

PRACTICALS- DSE LAB: EMBEDDED SYSTEM: INTRODUCTION TO MICROCONTROLLERS

60 Periods

8051 microcontroller based Programs and experiments (at least 06 experiments):

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 clockwise or counter clockwise direction.
11. Application of embedded systems: Temperature measurement, some information on LCD display, interfacing a keyboard.

Arduino based programs and experiments:

12. Make a LED flash at different time intervals.
13. To vary the intensity of LED connected to Arduino.
14. To control speed of a stepper motor using a potential meter connected to Arduino
15. To display “PHYSICS” on LCD/CRO.

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

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

Theory: 75 Lectures
The objective of the course is to impart the understanding of the sub atomic particles and their properties. It will emphasize to gain knowledge about the different nuclear techniques and their applications in different branches of Physics and societal application. The course will focus on the developments of problem based skills. The acquire knowledge can be applied in the areas of nuclear, medical, archeology, geology and other interdisciplinary fields of Physics and Chemistry. It will enhance the special skills required for these fields.

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

Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, nucleon separation energies(up to two nucleons), Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure and the basic assumption of shell model (11 Lectures)

Radioactivity decay: Decay rate and equilibrium (Secular and Transient) (a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy, decay Chains. (b) β-decay: energy kinematics for β-decay, β-spectrum, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission from the excited state of the nucleus & kinematics, internal conversion. (10 Lectures)

Nuclear Reactions: Types of Reactions, units of related physical quantities, 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)
**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.  
(9 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.  
(9 Lectures)

**Particle Accelerators:** Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons (Principal, construction, working, advantages and disadvantages).  
(7 Lectures)

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

**Reference Books:**
- Radiation detection and measurement, G.F. Knoll, John Wiley &amp; Sons, 2010.

**For Numericals**
- Schaum’s Outline of Modern Physics, McGraw-Hill Education, 1999

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**PHYSICS-DSE: PHYSICS OF DEVICES AND COMMUNICATION**
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures
This paper is based on advanced electronics which covers the devices such as UJT, JFET, MOSFET, CMOS etc. Process of IC fabrication is discussed in detail. Digital Data serial and parallel Communication Standards are described along with the understanding of communication systems.

**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. SiO₂-Si based MOS, C-V characteristics of MOS, MOSFET– their frequency limits. Enhancement and Depletion Mode MOSFETS, CMOS. Charge coupled devices.  

(17 Lectures)


(14 Lectures)

RC Filters: Passive-Low pass and High pass filters, Active (1st order butterworth) - Low Pass, High Pass, Band Pass and band Reject Filters.  

(3 Lectures)

Phase Locked Loop (PLL): Basic Principles, Phase detector (XOR and edge triggered), Voltage Controlled Oscillator (Basics, varactor). Lock and capture. Basic idea of PLL IC (565 or 4046).  

(6 Lectures)

**Digital Data Communication Standards:**  
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.  

(5 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. Frequency modulation and demodulation, basic idea of Frequency, Phase, Pulse and Digital Modulation including ASK, PSK, FSK.  

(15 lectures)

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

PRACTICAL- DSE LAB: PHYSICS OF DEVICES AND INSTRUMENTS
60 Periods
At least 06 experiments each from section-A and section-B:
Section-A:
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.

Section-B: SPICE/MULTISIM simulations for electronic circuits and devices
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

**PHYSICS-DSE: Astronomy and Astrophysics**

(Credits: Theory-05, Tutorials-01)

**Theory: 75 Lectures**

The syllabus of "Astronomy and Astrophysics" has been designed in a manner that provides excellent platform for understanding the origin and evolution of the Universe. It gives a comprehensive introduction on the measurement of basic astronomical parameters such as astronomical scales, luminosity and astronomical quantities. This course gives an overview on key developments in observational astrophysics. This primarily includes the telescope optics, instrument detectors and the choice of observation sites. The syllabus also reviews the formation of planetary system and its evolution with time. This course nicely covers the physical properties of Sun and the components of the solar system; and stellar and interstellar components of our Milky Way galaxy. It emphasizes on the physical laws that enable us to understand the origin and evolution of galaxies, presence of dark matter and large scale structures of the Universe.

**Basic Astronomical Parameters:** Astronomical scales (Distance, Mass and Time), Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus, Measurement of Astronomical Quantities (Distances, Stellar Radii, Masses of Stars from binary orbits, Stellar Temperature, Color index of stars).

**Basic concepts of positional astronomy:** Celestial Sphere, Geometry of a Sphere, Astronomical Coordinate Systems, Horizon System, Equatorial System, Coordinate transformation between Horizon and Equatorial system, Diurnal Motion of the Stars. Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Julian Date.

**Stellar spectra:** Spectral types and their temperature dependence, Hertzsprung-Russell Diagram.

**Astronomical telescopes and techniques:** Atmospheric Windows, Optical telescopes,
Radio telescope, Telescope mountings, Magnification, Light gathering power, resolving power and diffraction limit, Detection limit of telescope, Modern terrestrial and space telescopes (GMRT, Keck, Chandra, HST) (8 Lectures)

**Stellar structure:** Derivation of Virial Theorem for N bodies, Basic Equations of stellar structure, simple stellar models (Polytropic model, Derivation of the Lane-Emden equation, analytical solutions of the Lane-Emden equation) (14 Lectures)


**Large Scale Structure and Expanding Universe:** Main sequence fitting, Standard candles (Cepheid variables, Supernovae), Cosmic Distance Ladder, Clusters of Galaxies (Virial theorem and Dark Matter), Hubble’s Law (9 Lectures)

**Reference Books:**
- Introductory Astronomy and Astrophysics (Fourth Edition), M. Zeilik and S. A. Gregory
- The Physical Universe: An Introduction to Astronomy, Frank Shu, Oxford University Press, 1985

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

*This paper aims to describe the characteristics of earth’s atmosphere and also its dynamics. Atmospheric waves along with the basic concepts of atmospheric Radar and Lidar are discussed in detail.*
**General features of Earth’s atmosphere:** Thermal structure of the Earth’s Atmosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics, Greenhouse effect, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations including RS/RW, meteorological processes and convective 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, Quasi biennial oscillation, annual and semi-annual 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, Applications 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:**
- Fundamental of Atmospheric Physics, M.L Salby; Academic Press, Vol 61, 1996
- An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004

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**PRACTICALS-DSE LAB: Atmospheric Physics**

60 Periods
Scilab/C++ based simulations experiments based on Atmospheric Physics problems like (at least 05 experiments)

1. Numerical Simulation for atmospheric waves using dispersion relations
   (a) Atmospheric gravity waves (AGW)
   (b) Kelvin waves
   (c) Rossby waves, and mountain waves

2. Offline and online processing of radar data
   (a) VHF radar,
   (b) X-band radar, and
   (c) UHF radar

3. Offline and online processing of LIDAR data

4. Radiosonde data and its interpretation in terms of atmospheric parameters using vertical profiles in different regions of the globe.

5. Handling of satellite data and plotting of atmospheric parameters using radio occultation technique

6. Time series analysis of temperature using long term data over metropolitan cities in India – an approach to understand the climate change

7. PM 2.5 measurement using compact instruments

8. Field visits to National center for medium range weather forecasting, India meteorological departments, and ARIES Nainital to see onsite radiosonde balloon launch, simulation on computers and radar operations on real time basis.

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

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PHYSICS-DSE: Biological Physics
(Credits: Theory-05, Tutorials-01)

Theory: 75 Lectures

The Biological Physics course introduces the emerging inter-disciplinary field on the interface of Physics and Biology. It makes use of concepts from Physics and discusses their application in Biology. This course helps the students to develop a system level perspective of Biology and equips them with the required mathematical and computational skills.

Overview: (9 Lectures)

Molecules of life: (22 Lectures)
Metabolites, proteins and nucleic acids. Their sizes, types and roles in structures and processes. Transport, energy storage, membrane formation, catalysis, replication, transcription, translation, signaling.
Typical populations of molecules of various types present in cells, their rates of production and turnover. Energy required to make a bacterial cell.
Simplified mathematical models of transcription and translation, small genetic circuits and signaling pathways. Random walks and applications to biology. Mathematical models to be studied analytically and computationally.

The complexity of life: (30 Lectures)

At the level of a multicellular organism: Numbers and types of cells in multicellular organisms. Cell types as distinct attractors of a dynamical system. Stem cells and cellular differentiation. Pattern formation and development.

At the level of an ecosystem and the biosphere: Foodwebs. Feedback cycles and self-sustaining ecosystems.

Evolution: (14 Lectures)
The mechanism of evolution: variation at the molecular level, selection at the level of the organism. Models of evolution. The concept of genotype-phenotype map. Examples.

Reference Books:
- Physics in Molecular Biology; Kim Sneppen & Giovanni Zocchi (CUP 2005)
Even Semester Options (DSE III – IV, Dissertation): Select any 02 papers

PHYSICS-DSE: Advanced Mathematical Physics –II
(Credits: Theory-05, Tutorial-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.

Calculus of Variations:

(25 Lectures)

Group Theory:
Review of sets, Mapping and Binary Operations, Relation, Types of Relations.

(25 Lectures)

Advanced Probability Theory:

(25 Lectures)

Reference Books:
PHYSICS- DSE 1C: COMMUNICATION SYSTEM
(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

This paper aims to describe the concepts of electronics in communication. Communication techniques based on Analog Modulation, Analog and digital Pulse Modulation including PAM, PWM, PPM, ASK, PSK, FSK are described in detail. Communication and Navigation systems such as GPS and mobile telephony system are introduced.


Analog Modulation: Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Super heterodyne receiver. (12 Lectures)

Analog Pulse Modulation: Channel capacity, Sampling theorem, Basic Principles-PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing. (9 Lectures)

Digital Pulse Modulation: Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques, Sampling, Quantization and Encoding, Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK). (10 Lectures)

Mobile Telephony System – Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only), GPS navigation system (qualitative idea only). (15 Lectures)

Reference Books:
- Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
- Communication Systems, S. Haykin, 2006, Wiley India
- Wireless communications, Andrea Goldsmith, 2015, Cambridge University Press

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PHYSICSS LAB-DSE LAB: COMMUNICATION SYSTEM LAB
60 Periods

AT LEAST 05 EXPERIMENTS FROM THE FOLLOWING
1. To design an Amplitude Modulator using Transistor
2. To study envelope detector for demodulation of AM signal
3. To study FM - Generator and Detector circuit
4. To study AM Transmitter and Receiver
5. To study FM Transmitter and Receiver
6. To study Time Division Multiplexing (TDM)
7. To study Pulse Amplitude Modulation (PAM)
8. To study Pulse Width Modulation (PWM)
9. To study Pulse Position Modulation (PPM)
10. To study ASK, PSK and FSK modulators

Reference Books:

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PHYSICS-DSE: APPLIED DYNAMICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures
This course begins with the first order dynamical system and the idea of phase space, flows and trajectories and ends with the elementary fluid dynamics. Students will also appreciate the introduction to chaos and fractals. The emphasis of this course is to enhance the understanding of the basics of applied dynamics. By the end of this course, students should be able to solve the seen or unseen problems/numericals in applied dynamics.

**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: simple and damped harmonic oscillator. Sketching flows and trajectories in phase space. Fixed points, attractors, stability of fixed points, basin of attraction, notion of qualitative analysis of dynamical systems.

Examples of dynamical systems –
Population models e.g. exponential growth and decay, logistic growth, predator-prey dynamics. Rate equations for chemical reactions e.g. auto catalysis, bistability

(22 Lectures)


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.

Nonlinear time series analysis and chaos characterization: Detecting chaos from Return map, Power spectrum, Autocorrelation, Lyapunov exponent, Correlation dimension.

(22 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 and non-uniform flows, viscous and inviscid flows, incompressible and compressible flows, laminar and turbulent flows, rotational and irrotational flows, separated and unseparated flows. Flow visualization - streamlines, pathlines, Streaklines.

(16 Lectures)

**Reference Books**

- Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
PHYSICS PRACTICAL-DSE LAB: APPLIED DYNAMICS
60 Periods

*Computing and visualizing trajectories using software such as Scilab, Maple, Octave, XPPAUT based on Applied Dynamics problems like (at least 06 experiments)*

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, predator-prey dynamics.
5. To study rate equations for chemical reactions e.g. auto catalysis, bistability.
6. To study examples from game theory.
7. To study period doubling route to chaos in logistic map.
8. To study various attractors of Lorenz equations.
11. Computational visualization of fractal formations of Fractals in nature – trees, coastlines, earthquakes.

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

PHYSICS-DSE: VERILOG AND FPGA BASED SYSTEM DESIGN
(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

*This paper provides a review of combinational and sequential circuits such as multiplexers, demultiplexers, decoders, encoders and adder circuits. Evolution of Programmable logic devices such as PAL, PLA and GAL is explained. At the end of the*
syllabus, students will be able to understand the modeling of combinational and sequential circuits (including FSM and FSMD) with Verilog Design.


Verilog HDL: Introduction to HDL. Verilog primitive operators and structural Verilog Behavioral Verilog. Design verification. Modeling of combinational and sequential circuits (including FSM and FSMD) with Verilog Design examples in Verilog. (20 lectures)

Reference Books:

PRACTICALS-DSE LAB: VERILOG AND FPGA LAB
60 Periods

AT LEAST 08 EXPERIMENTS FROM FOLLOWING.
1. Write code to realize basic and derived logic gates.
2. Half adder, Full Adder using basic and derived gates.
3. Half subtractor and Full Subtractor using basic and derived gates.
5. Multiplexer (4x1) and Demultiplexer using logic gates.
6. Decoder and Encoder using logic gates.
7. Clocked D, JK and T Flip flops (with Reset inputs)
8. 3-bit Ripple counter
9. To design and study switching circuits (LED blink shift)
10. To design traffic light controller.
11. To interface a keyboard
12. To interface a LCD using FPGA
13. To interface multiplexed seven segment display.
14. To interface a stepper motor and DC motor.
15. To interface ADC 0804.

Reference Books
- Verilog HDL primer- J. Bhasker. BSP, 2003 II edition

PHYSICS-DSE: CLASSICAL DYNAMICS
(Credits: Theory-05, Tutorials-01)

Theory: 75 Lectures
This course begins with the review of Newton’s Laws of Motion and ends with the Special Theory of Relativity by 4-vector approach and fluids. Students will also appreciate the Lagrangian and Hamiltonian Mechanics. The emphasis of this course is to enhance the understanding of Classical Mechanics (Lagrangian and Hamiltonian Approach). By the end of this course, students should be able to solve the seen or unseen problems/numericals in classical mechanics.

Small Amplitude Oscillations: Minima of potential energy and points of stable equilibrium, small amplitude oscillations about the minimum, normal modes of longitudinal simple harmonic oscillations (maximum 3 masses connected by 4 springs). Kinetic energy (T) and potential energy (V) in terms of normal co-ordinates. T and V matrices: finding eigen-frequencies and eigen-vectors using these matrices. (10 Lectures)

Special Theory of Relativity: Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time-dilation, length contraction, simultaneity Four-vectors: space-like, time-like and light-like. Four-displacement \([X^\mu = (ct, \mathbf{r})]\), 4-velocity \([U^\mu = \gamma(c, \mathbf{u})]\), 4-acceleration \((A^\mu)\). Metric tensor \((g^{\mu\nu} \text{ or } g_{\mu\nu})\) and alternating tensor \((\varepsilon^{abcd} \text{ or } \varepsilon_{abcd})\) and their properties. Four-momentum \([P^\mu = (E/c, \mathbf{p})]\) and energy-momentum relation. Concept of four-force \((F^\mu)\). Transformation Laws of Four-force. Norms: \(X^\mu X_\mu, U^\mu U_\mu, A^\mu A_\mu, F^\mu F_\mu\). Orthogonal relations: \(U^\mu A_\mu = 0, P^\mu F_\mu = 0\). Conservation of four-momentum. Lagrangian and Hamiltonian of a relativistic free particle. (35 Lectures)

Fluid Dynamics: Density \(\rho\) and pressure \(P\) in a fluid, an element of fluid and its velocity, continuity equation and mass conservation, stream-lined motion, laminar flow, Poiseuille’s equation for flow of a liquid through a pipe. (5 Lectures)

Reference Books:
- Classical Mechanics, Tai L. Chow, CRC Press.

PHYSICS-DSE: DIGITAL SIGNAL PROCESSING
(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures
This paper describes the discrete-time signals and systems, Fourier Transform Representation of Aperiodic Discrete-Time Signals. This paper also highlights the concept of filters and realization of Digital Filters. At the end of the syllabus, students will develop the understanding of Discrete and fast Fourier Transform.

Discrete-Time Signals and Systems: Classification of Signals, Transformations of the Independent Variable, Periodic and Aperiodic Signals, Energy and Power Signals, Even and Odd Signals, Discrete-Time Systems, System Properties. Impulse Response, Convolution Sum; Graphical Method; Analytical Method, Properties of Convolution; Commutative; Associative; Distributive; Shift; Sum Property System Response to
Periodic Inputs, Relationship Between LTI System Properties and the Impulse Response; Causality; Stability; Invertibility, Unit Step Response. *(10 Lectures)*

**Discrete-Time Fourier Transform:** Fourier Transform Representation of Aperiodic Discrete-Time Signals, Periodicity of DTFT, Properties; Linearity; Time Shifting; Frequency Shifting; Differencing in Time Domain; Differentiation in Frequency Domain; Convolution Property. **The z-Transform:** Bilateral (Two-Sided) z-Transform, Inverse z-Transform, Relationship Between z-Transform and Discrete-Time Fourier Transform, z-plane, Region-of-Convergence; Properties of ROC, Properties; Time Reversal; Differentiation in the z-Domain; Power Series Expansion Method (or Long Division Method); Analysis and Characterization of LTI Systems; Transfer Function and Difference-Equation System. Solving Difference Equations. *(15 Lectures)*

**Filter Concepts:** Phase Delay and Group delay, Zero-Phase Filter, Linear-Phase Filter, Simple FIR Digital Filters, Simple IIR Digital Filters, All pass Filters, Averaging Filters, Notch Filters. *(5 Lectures)*

**Discrete Fourier Transform:** Frequency Domain Sampling (Sampling of DTFT), The Discrete Fourier Transform (DFT) and its Inverse, DFT as a Linear transformation, Properties; Periodicity; Linearity; Circular Time Shifting; Circular Frequency Shifting; Circular Time Reversal; Multiplication Property; Parseval’s Relation, Linear Convolution Using the DFT (Linear Convolution Using Circular Convolution), Circular Convolution as Linear Convolution with aliasing. *(10 Lectures)*

**Fast Fourier Transform:** Direct Computation of the DFT, Symmetry and Periodicity Properties of the Twiddle factor (WN), Radix-2 FFT Algorithms; Decimation-In-Time (DIT) FFT Algorithm; Decimation-In-Frequency (DIF) FFT Algorithm, Inverse DFT Using FFT Algorithms. *(5 Lectures)*

**Realization of Digital Filters:** Non Recursive and Recursive Structures, Canonic and Non Canonic Structures, Equivalent Structures (Transposed Structure), FIR Filter structures; Direct-Form; Cascade-Form; Basic structures for IIR systems; Direct-Form I. **Finite Impulse Response Digital Filter:** Advantages and Disadvantages of Digital Filters, Types of Digital Filters: FIR and IIR Filters; Difference Between FIR and IIR Filters, Desirability of Linear-Phase Filters, Frequency Response of Linear-Phase FIR Filters, Impulse Responses of Ideal Filters, Windowing Method; Rectangular; Triangular; Kaiser Window, FIR Digital Differentiators. **Infinite Impulse Response Digital Filter:** Design of IIR Filters from Analog Filters, IIR Filter Design by Approximation of Derivatives, Backward Difference Algorithm, Impulse Invariance Method. *(15 Lectures)*

**Reference Books:**
- Digital Signal Processing, Tarun Kumar Rawat, 2015, Oxford University Press, India
PRACTICAL-DSE LAB: DIGITAL SIGNAL PROCESSING LAB

60 Periods

At least 06 experiments from the following using Scilab/Matlab. Introduction to Numerical computation software Scilab/Matlab be introduced in the lab.

1. Write a program to generate and plot the following sequences: (a) Unit sample sequence \( \delta(n) \), (b) unit step sequence \( u(n) \), (c) ramp sequence \( r(n) \), (d) real valued exponential sequence \( x(n) = (0.8)^n u(n) \) for \( 0 \leq n \leq 50 \).

2. Write a program to compute the convolution sum of a rectangle signal (or gate function) with itself for \( N = 5 \)

\[ x(n) = \text{rect} \left( \frac{n}{2N} \right) = \Pi \left( \frac{n}{2N} \right) = \begin{cases} 1 & -N \leq n \leq N \\ 0 & \text{otherwise} \end{cases} \]

3. An LTI system is specified by the difference equation

\[ y(n) = 0.8y(n-1) + x(n) \]

(a) Determine \( H(e^{j\omega}) \)

(b) Calculate and plot the steady state response \( y_{ss}(n) \) to

\[ x(n) = \cos(0.5\pi n)u(n) \]

4. Given a casual system

\[ y(n) = 0.9y(n-1) + x(n) \]

(a) Find \( H(z) \) and sketch its pole-zero plot

(b) Plot the frequency response \( |H(e^{j\omega})| \) and \( \angle H(e^{j\omega}) \)

5. Design a digital filter to eliminate the lower frequency sinusoid of \( x(t) = \sin 7t + \sin 200t \). The sampling frequency is \( f_s = 500 \text{ Hz} \). Plot its pole zero diagram, magnitude response, input and output of the filter.

6. Let \( x(n) \) be a 4-point sequence:

\[ x(n) = \begin{cases} 1,1,1,1 \uparrow & \text{for } 0 \leq n \leq 3 \\ 0 & \text{otherwise} \end{cases} \]
Compute the DTFT $X(e^{jw})$ and plot its magnitude

(a) Compute and plot the 4 point DFT of $x(n)$
(b) Compute and plot the 8 point DFT of $x(n)$ (by appending 4 zeros)
(c) Compute and plot the 16 point DFT of $x(n)$ (by appending 12 zeros)

7. Let $x(n)$ and $h(n)$ be the two 4-point sequences,

\[ x(n) = \{1,2,2,1\} \uparrow \]
\[ h(n) = \{1,-1,-1,1\} \uparrow \]

Write a program to compute their linear convolution using circular convolution.

8. Using a rectangular window, design a FIR low-pass filter with a pass-band gain of unity, cut off frequency of 1000 Hz and working at a sampling frequency of 5 KHz. Take the length of the impulse response as 17.

9. Design an FIR filter to meet the following specifications:
   - passband edge $F_p = 2$ KHz
   - stopband edge $F_s = 5$ KHz
   - Passband attenuation $A_p = 2$ dB
   - Stopband attenuation $A_s = 42$ dB
   - Sampling frequency $F_s = 20$ KHz

10. The frequency response of a linear phase digital differentiator is given by

\[ H_d(e^{jw}) = jwe^{-j\tau w} \text{ for } |w| \leq \pi \]

Using a Hamming window of length $M = 21$, design a digital FIR differentiator. Plot the amplitude response.

Reference Books:
- Digital Signal Processing, Tarun Kumar Rawat, Oxford University Press, India.
- Getting started with MATLAB, Rudra Pratap, 2010, Oxford University Press.

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

Theory: 60 Lectures

This course introduces the essence of nano materials, their synthesis, and characterization. On successful completion of the module students should also be able to understand the optical properties and electron transport phenomenon in nanostructures. It also covers few important applications of nano materials used in this technological era.

NANOSCALE SYSTEMS: Density of states (1-D,2-D,3-D). 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, 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:
- C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
- Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).

PRACTICALS-DSE LAB: Nano Materials and Applications
60 Lectures

At least 04 experiments from the following:
1. Synthesis of metal nanoparticles by chemical route.
2. Synthesis of semiconductor nanoparticles.
3. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.
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:
- C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
- Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).

PHYSICS-DSE: Physics of Earth
(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.
(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: layers, variation of temperature with altitude, adiabatic lapse rate, variation of density and pressure with altitude, cloud formation.
(d) The Cryosphere: Polar caps and ice sheets. Mountain glaciers, permafrost.

3. **Dynamical Processes:** *(18 Lectures)*

Climate:
- Earth’s temperature and greenhouse effect.
- Paleoclimate and recent climate changes.
- The Indian monsoon system.
(d) Biosphere: Water cycle, Carbon cycle. The role of cycles in maintaining a steady state.

4. **Evolution:** (18 Lectures)
Role of the biosphere in shaping the environment. Future of evolution of the Earth and solar system: Death of the Earth (Probable causes).

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:**
- Consider a Spherical Cow: A course in environmental problem solving, John Harte, University Science Books
- IGNOU Study material: PHE 15 Astronomy and Astrophysics Block 2
PHYSICS-DSE: Medical Physics

Credits: Theory-04, Practicals-02

Theory: 60 Lectures

The last few years have witnessed a tremendous growth in the applications of Physics to the field of medicine. Beginning with the use of Imaging in Diagnostics to Radiation therapy for Cancer, everything involves Physics. Hence, there is a big need for being aware of medical physics. This course introduces a student to the basics of Medical Physics. Today with the changing life styles it is also necessary for one to have a better understanding of the human body from the perspective of Physics. This course seeks to fulfil both these needs.

PHYSICS OF THE BODY-I


Mechanics of the body: Skeleton, forces, and body stability. Muscles and dynamics of body movement.


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.

PHYSICS OF DIAGNOSTIC AND THERAPEUTIC SYSTEMS-I


Radiation Physics: Radiation units exposure, absorbed dose, units: rad, gray, relative biological effectiveness, effective dose- Rem & Sievert, inverse square law. Interaction of radiation with matter Compton & photoelectric effect, linear attenuation coefficient. Radiation Detectors: ionization (Thimble chamber, condenser chamber), chamber. Geiger Muller counter, Scintillation counters and Solid-State detectors, TFT.
MEDICAL IMAGING PHYSICS: Evolution of Medical Imaging, X-ray diagnostics and imaging, Physics of nuclear magnetic resonance (NMR), NMR imaging, MRI. Radiological imaging, Ultrasound imaging, Physics of Doppler with applications and modes, Vascular Doppler. Radiography: Filters, grids, cassette, X-ray film, film processing, fluoroscopy. Computed tomography scanner- principle and function, display, generations, mammography. Thyroid uptake system and Gamma camera (Only Principle, function and display). (9 Lectures)

RADIATION ONCOLOGY PHYSICS: External Beam Therapy (Basic Idea): Telecobalt, Conformal Radiation Therapy (CRT), 3DCRT, IMRT, Image Guided Radiotherapy, EPID, Rapid Arc, Proton Therapy, Gamma Knife, Cyber Knife. Contact Beam Therapy (Basic Idea): Brachytherapy-LDR and HDR, Intra Operative Brachytherapy. Radiotherapy, kilo voltage machines, deep therapy machines, Telecobalt machines, Medical linear accelerator. Basics of Teletherapy units, deep X-ray, Telecobalt units, Radiation protection, external beam characteristics, dose maximum and build up – bolus, percentage depth dose, tissue maximum ratio and tissue phantom ratio, Planned target Volume and Gross Tumour Volume. (9 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. Medical Instrumentation: Basic Ideas of Endoscope and Cautery, Sleep Apnea and Cpap Machines, Ventilator and its modes. (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)
- Handbook of Physics in Diagnostic Imaging: R.S.Livingstone: B.I. Publication Pvt Ltd.
- The Physics of Radiology-H E Johns and Cunningham.
PHYSICS-DSE LAB: Medical Physics

60 Periods

At least 05 experiments from the following:

1. Understanding the working of a manual Hg Blood Pressure monitor, Stethoscope and to measure the Blood Pressure.

2. Basic Process of doing CPR.

3. Understanding the working of a manual optical eye-testing machine and to learn eye-testing procedure.

4. Correction of Myopia (short sightedness) using a combination of lenses on an optical bench/breadboard.

5. Correction of Hypermetropia/Hyperopia (long sightedness) using a combination of lenses on an optical bench/breadboard.

6. To learn working of Thermoluminescent dosimeter (TLD) badges and measure the background radiation.

7. Familiarization with Geiger-Muller (GM) Counter & to measure background radiation.

8. Familiarization with Radiation meter and to measure background radiation.


Reference Books:

- Christensen’s Physics of Diagnostic Radiology: Curry, Dowdey and Murry - Lippincot Williams and Wilkins (1990)

PHYSICS – DSE: ADVANCED QUANTUM MECHANICS

(Credits: Theory -05, Tutorial -01)

Theory: 75 Lectures


(17 lectures)


Dynamics of two-level systems (e.g. electron in an external magnetic field).  

One dimensional Harmonic oscillator using ladder operators.  

Addition of orbital and spin angular momenta, $J = L+S$. Commutators of $J_x$, $J_y$ and $J_z$; ladder operators, eigenvalues and eigenstates of total angular momentum operators. Composite system of two spin-half particles – singlet and triplet states. Clebsch-Gordan coefficients: formalism, computation (up to 1 x $\frac{1}{2}$)  

Variational Method: Basic idea, application to some simple systems. Hydrogen atom ground state energy. Helium atom ground state energy.  

Reference Books:

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

PHYSICS WORKSHOP SKILL
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 devices: Vernier calliper, Screw gauge and travelling microscope. 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. (6 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. (10 Lectures)

Practical

Main emphasis is on taking observations, calculations, graph and result. Perform at least three practical from the following.

1. Comparison of diameter of a thin wire using screw gauge and travelling microscope.
2. Drilling of Hole in metal, wood and plastic.
3. Cutting of metal sheet.
4. Cutting of glass sheet
5. Lifting of heavy weights using simple pulley/lever arrangement.

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

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COMPUTATIONAL PHYSICS

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 and Science.

- Highlights the use of computational methods to solve physical problems
- Use of computer language as a tool in solving physics/science problems
- 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)


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 CIRCUITS AND NETWORK SKILLS**

**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. (2 Lectures)

Electric Motors: Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters and motors. Speed & power of ac motor. (3 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)


Network Theorems: (1) Thevenin theorem (2) Norton theorem (3) Superposition theorem (4) Maximum Power Transfer theorem. (3 Lectures)

Laboratory exercises:

AT LEAST 08 EXPERIMENTS FROM THE FOLLOWING
1. Series and Parallel combinations: Verification of Kirchoff’s law.
2. To verify network theorems: (I) Thevenin (II) Norton (III) Superposition theorem
(IV) Maximum power transfer theorem
3. To study frequency response curve of a Series LCR circuit.
4. To verify (1) Faraday’s law and (2) Lenz’s law.
5. Programming with Pspice/NG spice.
6. Demonstration of AC and DC generator.
7. Speed of motor
8. To study the characteristics of a diode.
9. To study rectifiers (I) Half wave (II) Full wave rectifier (III) Bridge rectifier
10. Power supply (I) C-filter, (II) π- filter
11. Transformer – Step up and Step down
12. Preparation of extension board with MCB/fuse, switch, socket-plug, Indicator.
13. Fabrication of Regulated power supply.

Reference Books:
• Electrical Circuits, K.A. Smith and R.E. Alley, 2014, Cambridge University Press
• 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.

BASIC INSTRUMENTATION SKILLS
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. Block diagram of ac millivoltmeter, specifications and their significance. (4 Lectures)

Oscilloscope: Block diagram of basic CRO. CRT, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence. Time base operation, synchronization. Front panel controls. Specifications of CRO and their significance. (6 Lectures)

Use of CRO for the measurement of voltage (dc and ac), frequency and time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: principle of working. (3 Lectures)
**Signal and pulse Generators:** Block diagram, explanation and specifications of low frequency signal generator and pulse generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis.  

(4 Lectures)

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

(3 Lectures)


(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. Oscilloscope 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 using Oscilloscope.
5. Measurement of time period, frequency, average period using universal counter/frequency counter.

**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.

RENEWABLE ENERGY AND ENERGY HARVESTING
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, B.H. Khan, McGraw Hill
- Renewable Energy, 3rd Edition,
- J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).

**Engineering Design and Prototyping**

**Theory:** 30 Lectures

"How I See is How I Understand"

*Drawings and pictorial representations are simple but effective tools in engineering crafts and one of the best ways to communicate ideas, learnings, and concepts. The purpose of this SEC is to empower the learners to think computationally and communicate pictorially.*

**Introduction:** Fundamentals of Engineering design, design process and sketching: Scales and dimensioning, Designing to Standards (ISO Norm Elements/ISI), Engineering Curves: Parabola, hyperbola, ellipse and spiral.  
(4 Lectures)

(10 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 of Inquiry commands to extract drawing data. Control entity properties. Demonstrating basic skills to produce 2-D drawings. Annotating in Auto CAD with text and hatching, layers, templates and design centre, advanced plotting (layouts, viewports), office standards, dimensioning, internet
and collaboration, Blocks, Drafting symbols, attributes, extracting data. Basic printing and editing tools, plot/print drawing to appropriate scale. (10 Lectures)

**Computer Aided Design and Prototyping:** 3D modeling with AutoCAD (surfaces and solids), 3D modeling with Sketchup, 3D designs, Assembly: Model Editing; Lattice and surface optimization; 2D and 3D packing algorithms, Additive Manufacturing Ready Model Creation (3D printing), Technical drafting and Documentation. (6 Lectures)

**References:**
- Engineering Graphic, K. Venugopal and V. Raja Prabhu, New Age International
- Engineering Drawing, Dhananjay A Jolhe, McGraw-Hill

**Reference Books:**
- Engineering Graphic, K. Venugopal, and V. Raja Prabhu, New Age International

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**RADIATION SAFETY**
**Theory:** 30 Lectures

*It is a course focus on the applications of nuclear techniques and radiation protection. It will not only enhance the skills towards the basic understanding of the radiation but will also provide the knowledge about the protective measures against the radiation exposure. This will prepare the work force for jobs in industry and medical fields. 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 Geiger 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), Archeology, Art, Crime detection, Mining and oil. Industrial Uses: Tracing, Gauging, Material Modification, Sterilization, Food preservation. (5 Lectures)

**Experiments:** Minimum four experiments need to be perform from the following,

1. Estimate the energy loss of different ions in Water and carbon, using SRIM/TRIM etc simulation software.
2. Simulation study (using SRIM/TRIM or any other software) of radiation depth in materials (Carbon, Silver, Gold, Lead) using H-ion.
3. Comparison of interaction of H like ions in a given medium (Carbon/Water) using simulation software (SRIM etc).
4. Study the background radiation in different places and identify the source material from gamma ray energy spectrum. (Data may be taken from the Department of Physics & Astrophysics, University of Delhi and gamma ray energies are available in the website http://www.nndc.bnl.gov/nudat2/)
5. Study the background radiation levels using Radiation meter .
6. Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).
8. Study of radiation in various materials (e.g. KSO4 etc.). Investigation of possible radiation in different routine materials by operating GM counter at operating voltage.
10. Detection of α particles using reference source & determining its half life using spark counter
11. Gamma spectrum of Gas Light mantle (Source of Thorium)

Reference Books:
- Thermoluminescence dosimetry by A. F. Mcknlay, Bristol, Adam Hilger (Medical Physics Hand book 5)
- IAEA Publications: (a) General safety requirements Part 1, No. GSR Part 1 (2010), Part 3
- AERB Safety Standard No. AERB/SS/3 (Rev. 1), Testing and Classification of sealed Radioactivity Sources. , 2007

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APPLIED OPTICS
THEORY: 30 Lectures
The quest to understand the 'nature of light' is a favorite inquiry of mankind since ancient times. By the advent of lasers, holography, and optical fibres in twentieth century the optics now-a-days finds application in several branches of science and engineering. This paper provides the conceptual understanding of these branches of modern optics to the students.
Theory includes only qualitative explanation. Minimum five experiments should be performed covering minimum three sections.
(i) **Photo-sources and Detectors** (9 lectures)
Lasers: an introduction, Planck’s radiation law (qualitative idea), Energy levels, Absorption process, Spontaneous and stimulated emission processes, Theory of laser action, Population of energy levels, Einstein’s coefficients and optical amplification, properties of laser beam, Ruby laser, He-Ne laser, and semiconductor lasers; Light Emitting Diode (LED) and photo-detectors.

**Experiments on Lasers:**
- a. To determine 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
- e. To determine the wavelength and angular spread of laser light by using plane diffraction grating.

**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. Characteristics of Photovoltaic Cell/ Photodiode.
- e. Characteristics of IR sensor

(ii) **Fourier Optics and Fourier Transform Spectroscopy** (Qualitative explanation) (6 lectures)
Concept of Spatial frequency filtering, Fourier transforming property of a thin lens, Fourier Transform Spectroscopy (FTS): measuring emission and absorption spectra, with wide application in atmospheric remote sensing, NMR spectrometry, and forensic science.

**Experiments on Fourier Optics:**
- a. Optical image addition/subtraction
- b. Optical image differentiation
- c. Fourier optical filtering
- d. Construction of an optical 4f system

**Experiments on Fourier Transform Spectroscopy**
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 lectures)
Introduction, Basic principle and theory: recording and reconstruction processes, Requirements of holography-coherence, etc. Types of holograms: The thick or volume hologram, Multiplex hologram, white light reflection hologram; application of holography in microscopy, interferometry, and
character recognition.

**Experiments on Holography and interferometry:**

a. Recording and reconstruction of holograms (Computer simulation can also be done).
b. To construct a Michelson interferometer or a Fabry Perot interferometer.
c. To determine the wavelength of sodium light by using Michelson’s interferometer.
d. To measure the refractive index of air.

(iv) **Photonics: Fibre Optics**  (9 lectures)

Optical fibres: Introduction and historical remarks, Total Internal Reflection, Basic characteristics of the optical fibre: Principle of light propagation through a fibre, the coherent bundle, The numerical aperture, Attenuation in optical fibre and attenuation limit; Single mode and multimode fibres, Fibre optic sensors: Fibre Bragg Grating.

**Experiments on Fibre Optics**

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

**Reference Books:**

- Introduction to Fiber Optics, A. Ghatak & K. Thyagarajan, Cambridge University Press.

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**WEATHER FORECASTING**

**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  (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 and its measurement, particulate matters PM 2.5, PM 10. Health hazards due to high concentration of PM2.5; aerosols, ozone depletion

(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.
   (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).
5. Simulation of weather system
6. Field visits to India Meteorological department and National center for medium range weather forecasting

Reference books:

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INTRODUCTION TO PHYSICAL COMPUTING
Theory: 30 Lectures

Physical computing is an interactive physical system that senses, processes and responds to our analog world. An embedded computer together with sensors and actuators to connect with the physical environment including human interaction, represents a common method of implementing a physical computing system.

Embedded computers have revolutionized our world. Embedded computers are much lower in cost and size and serve a single dedicated function of implementing and improving the function of the gadget. The study of elements of physical computing using embedded computers would be very beneficial towards implementing experimental setups in physics.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Topic</th>
<th>Lectures</th>
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<tbody>
<tr>
<td>1.</td>
<td>Brief overview of a computer. Evolution from CPU to Microprocessor to microcontroller. Introduction to Arduino</td>
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<tr>
<td>2.</td>
<td>Overview of basic electronic components (R, L, C, diode, BJT, Mosfet etc.) and circuits, 555 timer, logic gates, logic function ICs, power supply and batteries.</td>
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<td>3.</td>
<td>Capturing schematic diagrams. Using free software such as EagleCAD</td>
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<td>4.</td>
<td>Using basic lab instruments – DMM, oscilloscope, signal generator etc.</td>
<td>3</td>
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<td>5.</td>
<td>Understanding Arduino programming. Downloading and installing Arduino IDE. Writing an Arduino sketch.</td>
<td>2</td>
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<tr>
<td>6.</td>
<td>Programming fundamentals: program initialization, conditional statements, loops, functions, global variables.</td>
<td>3</td>
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<td>7.</td>
<td>Digital Input and Output</td>
<td>3</td>
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<td>8.</td>
<td>Measuring time and events. Pulse Width Modulation.</td>
<td>3</td>
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<tr>
<td>9.</td>
<td>Analog Input and Output</td>
<td>3</td>
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<td>10.</td>
<td>Physical Interface: sensors and actuators</td>
<td>3</td>
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<td>11.</td>
<td>Communication with the outside world.</td>
<td>2</td>
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<td>12.</td>
<td>System Integration and debugging.</td>
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List of Experiments/Projects

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<tr>
<th>S.No.</th>
<th>Experiments</th>
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93
1. **Hello LED**: Connect a LED to a digital output pin and turn it on and off.

2. **Hello Switch**: Read a switch and toggle an LED when the switch is pressed and released.

3. **Hello ADC**: Connect a potentiometer to an ADC input and print the analog voltage on the serial monitor.

4. **Hello Blink**: Read a switch and changing the LED blink rate every time the switch is pressed and released.

5. **Hello PWM**: Write a Pulse Width Modulation code in software and vary the LED intensity.

6. **Hello Random**: Read a switch and every time the switch is pressed and released, generate and print a random number on the serial monitor.

7. **Hello Random2**: Connect a Seven Segment Display (SSD) and print the random number on this display each time a switch is pressed and released. Collect large data sample and plot relative frequency of occurrence of each ‘random’ number.

8. **Hello LCD**: Connect a (16X2) LCD to an Arduino and print ‘Hello World’.

9. **Hello LCD2**: Connect a temperature sensor to an ADC input and print the temperature on the LCD.

10. **Hello PWM2**: Connect an RGB LED and 3 switches. Use hardware PWM feature of the Arduino and change the relative intensity of each of the LEDs of the RGB LED and generate large number of colors.

### Mini Projects

<table>
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<tr>
<th>S.No.</th>
<th>Description</th>
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<tbody>
<tr>
<td>1.</td>
<td>Connect 2 SSDs and every time a switch is pressed and released, print 2 random numbers on the two SSDs.</td>
</tr>
<tr>
<td>2.</td>
<td>Connect a switch and 4 RGB LEDs in a ‘Y’ configuration. Change the LED lighting patterns each time a switch is pressed and released (total 4095 patterns possible). Arrange acrylic mirrors in a triangle and make a LED kaleidoscope using the RGB LEDs as the light source.</td>
</tr>
<tr>
<td>3.</td>
<td>Connect a photo-gate mechanism to a bar pendulum. Verify that the period of oscillation is independent of the amplitude for small amplitudes. What happens when the amplitude is large?</td>
</tr>
<tr>
<td>4.</td>
<td>Connect 8 switches and a small speaker and an audio amplifier and make a piano.</td>
</tr>
</tbody>
</table>
5. Connect 2 sets of 3 switches for two players. Connect LCD and implement a ‘rock-paper-scissors’ game.

**Reference Books:**

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**NUMERICAL ANALYSIS**

**Theory: 30 Lectures**

The aim of the course is to analyze the basic techniques for the efficient numerical solution of problems in science and engineering. Topics include errors, iterative methods, root finding, interpolation, and approximation of functions, integration and differential equations.

**Errors and iterative Methods:** Truncation and Round-off Errors. Floating Point Computation, Overflow and underflow. Single and Double Precision Arithmetic, Iterative Methods. (2 Lectures)

**Solutions of Algebraic and Transcendental Equations:** (1) Fixed point iteration method, (2) Bisection method, (3) Secant Method, (4) Newton Raphson method, (5) Generalized Newton’s method. Comparison and error estimation (5+1 Lectures)

**Interpolation:** Forward and Backward Differences. Symbolic Relation, Differences of a polynomial. Newton’s Forward and Backward Interpolation Formulas (5 Lectures)

**Least Square fitting:** (1) Fitting a straight line. (2) Non-linear curve fitting: (a) Power function, (b) Polynomial of nth degree, and (c) Exponential Function. (3) Linear Weighed Least square Approximation (5 Lectures)

**Numerical Differentiation:** (1) Newton’s interpolation Formulas & (2) Cubic Spline Method, Errors in Numeric Differentiation. Maximum and Minimum values of a Tabulated Function (4 Lectures)


**Solution of Ordinary Differential Equations:** First Order ODE’s: solution of Initial Value problems: (1) Euler’s Method, (2) Modified Euler’s method (4 Lectures)

**Numerical Analysis Lab (Hands-on Exercises using C++/Sci lab programming)**

Algebraic and transcendental equation
1. To find the roots of an algebraic equation by Bisection method.
2. To find the roots of an algebraic equation by Secant method.
3. To find the roots of an algebraic equation by Newton-Raphson method.
4. To find the roots of a transcendental equation by Bisection method.

**Interpolation**
1. To find the forward difference table from a given set of data values.
2. To find a backward difference table from a given set of data values.

**Curve fitting**
1. To fit a straight line to a given set of data values.
2. To fit a polynomial to a given set of data values.
3. To fit an exponential function to a given set of data values.

**Differentiation**
1. To find the first and second derivatives near the beginning of the table of values of (x,y).
2. To find the first and second derivatives near the end of the table of values of (x,y).

**Integration**
1. To evaluate a definite integral by trapezoidal rule.
2. To evaluate a definite integral by Simpson 1/3 rule.
3. To evaluate a definite integral by Simpson 3/8 rule.
4. To evaluate a definite integral by Gauss Quadrature rule.

**Differential Equations**
1. To solve differential equations by Euler’s method
2. To solve differential equations by modified Euler’s method

**Reference Books:**

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**Generic Elective Papers (GE) (Minor-Physics) (any four- 01 from each group) for other Departments/Disciplines: (Credit: 06 each)**

1st SEMESTER: (Choose any one)

**GE: ELECTRICITY AND MAGNETISM**
(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

This course begins with elementary vector analysis, an essential mathematical tool for understanding static electric and magnetic field. By the end of the course student should appreciate Maxwell’s equations.

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

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

Magnetism:


Introduction to Maxwell’s equations

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 Periods
At least 05 experiments from the following:

1. 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.

2. To compare capacitances using De’Sauty’s bridge.

3. Measurement of field strength B and its variation in a Solenoid (Determine dB/dx)

4. To study the Characteristics of a Series RC Circuit.

5. To study a series LCR circuit and determine its (a) Resonant frequency, (b) Quality factor

6. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q

7. To determine a Low Resistance by Carey Foster’s Bridge.

8. To verify the Thevenin and Norton theorems

9. 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.
- Engineering Practical Physics, S. Panigrahi and B.Mallick, 2015, Cengage Learning India Pvt. Ltd.
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed.2011, Kitab Mahal

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)

Fourier Series: Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and
cosine functions and determination of Fourier coefficients. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. (10 Lectures)


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

**Partial Differential Equations:** Solutions to partial differential equations, using separation of variables: Laplace’s Equation in problems of rectangular geometry. Solution of 1D wave equation. (10 Lectures)


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

GE LAB: MATHEMATICAL PHYSICS

**60 Periods**

_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
- At least 12 programs must be attempted from the following

<table>
<thead>
<tr>
<th>Topics</th>
<th>Descriptions with Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction and Overview</td>
<td>Computer architecture and organization, memory and</td>
</tr>
<tr>
<td>Section</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>Basics of scientific computing</td>
<td>Input/output devices, Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow and overflow - emphasize the importance of making equations in terms of dimensionless variables, Iterative methods</td>
</tr>
<tr>
<td>Algorithms and Flow charts</td>
<td>Purpose, symbols and description</td>
</tr>
<tr>
<td>Introduction to C++</td>
<td>Introduction to Programming: Algorithms: Sequence, Selection and Repetition, Structured programming, basic idea of Compilers. Data Types, Enumerated Data, Conversion &amp; casting, constants and variables, Mathematical, Relational, Logical and Bitwise Operators. Precedence of Operators, Expressions and Statements, Scope and Visibility of Data, block, Local and Global variables, Auto, static and External variables. Programs: • To calculate area of a rectangle • To check size of variables in bytes (Use of sizeof() Operator)</td>
</tr>
<tr>
<td>C++ Control Statements</td>
<td>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, nested loops, break and continue statements Programs: • To find roots of a quadratic equation if…else And if…else if • To find largest of three numbers • To check whether a number is prime or not • To list Prime numbers up to 1000</td>
</tr>
<tr>
<td>Random Number generator</td>
<td>To find value of pi using Monte Carlo simulations</td>
</tr>
<tr>
<td>Arrays and Functions</td>
<td>Sum and 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 using Bubble sort and Sequential sort, Binary search,</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 [ \alpha = \tan \alpha; \quad I = I_0 \left( \frac{\sin \alpha}{\alpha} \right)^2 ] in optics,</td>
</tr>
<tr>
<td>Interpolation by Newton Gregory Forward &amp; Backward</td>
<td>Evaluation of trigonometric functions e.g. ( \sin \theta, \cos \theta, \tan \theta ) etc</td>
</tr>
<tr>
<td><strong>difference formula, Error estimation of linear interpolation</strong></td>
<td>Given Position with equidistant time data calculate velocity and acceleration and vice versa. Find the area of BH Hysteresis loop</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| **Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method** | First order differential equation  
- radioactive decay  
- Current in RC, LC circuits with DC source  
- Newton’s law of cooling  
- Classical equations of motion  
Also attempt the following problems using RK 4 order method  
- Solve the coupled differential equations  
\[
\frac{dx}{dt} = y + x - \frac{x^3}{3}; \quad \frac{dy}{dx} = -x
\]
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 \(0 \leq t \leq 15\) |

**Referred Books:**
- AnIntroductiontocomputationalPhysics,T.Pang,2nd Edn., 2006,CambridgeUniv. Press

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**GE: DIGITAL, ANALOG CIRCUITS AND INSTRUMENTATION**  
(Credits: Theory-04, Practicals-02)  
**Theory: 60 Lectures**

This paper aims to cover the basic digital and analog electronic systems. The concept of Boolean algebra is discussed in detail and arithmetic circuits are described. Students will learn the physics of semiconductor devices such as p-n junction, rectifier diodes and bipolar junction transistors. By the end of the syllabus, students will also have an understanding of operational amplifiers and instrumentation including CRO, power supply etc.

**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. NAND and NOR. Gates as Universal Gates. XOR and XNOR Gates. (5 Lectures)


UNIT-2: Semiconductor Devices and Amplifiers:

Semiconductor Diodes: P and N type semiconductors. PN junction and its characteristics. Static and dynamic Resistance. (2 Lectures)


UNIT-3: Operational Amplifiers (Black Box approach):


Sinusoidal Oscillators: Barkhausen's Criterion for Self-sustained Oscillations. Determination of Frequency of RC Phase-shift 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 Periods
AT LEAST 06 EXPERIMENTS FROM THE FOLLOWING
1. To measure (a) Voltage, and (b) Frequency of a periodic waveform using CRO
2. To minimize a given (a) logic circuit and (b) Boolean equation.
3. Half adder, Full adder and 4-bit Binary Adder.
4. To design an astable multivibrator of given specifications using 555 Timer.
5. To design a monostable multivibrator of given specifications using 555 Timer.
6. To study IV characteristics of (a) PN diode, (b) Zener diode and (3) LED.
7. To study the characteristics of a Transistor in CE configuration.
8. To design a CE amplifier of given gain (mid-gain) using voltage divider bias.
9. (a) To design an inverting amplifier of given gain using Op-amp 741 and study its frequency response.
   (b) To design a non-inverting amplifier of given gain using Op-amp 741 and study its Frequency Response.
11. To investigate a differentiator made using op-amp.
12. To design a Wien Bridge Oscillator using an op-amp.

Reference Books:
PHYSICS-GE: APPLIED DYNAMICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

This course begins with the first order dynamical system and the idea of phase space, flows and trajectories and ends with the elementary fluid dynamics. Students will also appreciate the introduction to chaos and fractals. The emphasis of this course is to enhance the understanding of the basics of applied dynamics. By the end of this course, students should be able to solve the seen or unseen problems/numericals in applied dynamics.

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: simple and damped harmonic oscillator. Fixed points, attractors, stability of fixed points, basin of attraction, notion of qualitative analysis of dynamical systems.
Examples of dynamical systems –
Population models e.g. exponential growth and decay, logistic growth, predator-prey dynamics.

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.
Nonlinear time series analysis and chaos characterization: Detecting chaos from Return map, Power spectrum, Autocorrelation, Lyapunov exponent, Correlation dimension.

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 and non-uniform flows, viscous and inviscid flows, incompressible and compressible flows, laminar and turbulent flows, rotational and irrotational flows, separated and unseparated flows.

Reference Books
• Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.

PHYSICS PRACTICAL-GE LAB: APPLIED DYNAMICS
60 Periods

Computing and visualizing trajectories using software such as Scilab, Maple, Octave, XPPAUT based on Applied Dynamics problems like (at least 06 experiments)

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, predator-prey dynamics.
5. To study rate equations for chemical reactions e.g. auto catalysis, bistability.
6. To study examples from game theory.
7. To study period doubling route to chaos in logistic map.
8. To study various attractors of Lorenz equations.
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
• Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer

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

The last few years have witnessed a tremendous growth in the applications of Physics to the field of medicine. Beginning with the use of Imaging in Diagnostics to Radiation therapy for Cancer, everything involves Physics. Hence, there is a big need for being aware of medical physics. This course introduces a student to the basics of Medical Physics. Today with the changing life styles it is also necessary for one to have a better understanding of the human body from the perspective of Physics. This course seeks to fulfill both these needs.

PHYSICS OF THE BODY-I

Mechanics of the body: Skeleton, forces, and body stability. Muscles and dynamics of body movement.
Other Systems in the body: Pressure system of body. Physics of breathing, Physics of cardiovascular system. (8 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, relative biological effectiveness, effective dose- Rem & Sievert, inverse square law. Interaction of radiation with matter Compton & photoelectric effect, linear attenuation coefficient. Radiation Detectors: ionization (Thimble chamber, condenser chamber), chamber. Geiger Muller counter, Scintillation counters and Solid-State detectors, TFT. (7 Lectures)

MEDICAL IMAGING PHYSICS: Evolution of Medical Imaging, X-ray diagnostics and imaging, Physics of nuclear magnetic resonance (NMR), NMR imaging, MRI Radiological imaging, Ultrasound imaging, Physics of Doppler with applications and modes, Vascular Doppler. Radiography: Filters, grids, cassette, X-ray film, film processing, fluoroscopy. Computed tomography scanner- principle and function,
display, generations, mammography. Thyroid uptake system and Gamma camera (Only Principle, function and display). 


PHYSICS OF DIAGNOSTIC AND THERAPEUTIC SYSTEMS-II

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)
• Physics of the human body, Irving P. Herman, Springer (2007).
• The essential physics of Medical Imaging: Bushberg, Seibert, Leidholdt and Boone Lippincot Williams and Wilkins, Second Edition (2002)
• Handbook of Physics in Diagnostic Imaging: R.S. Livingstone: B.I. Publication Pvt Ltd.
• The Physics of Radiology-H E Johns and Cunningham.

PHYSICS-GE LAB: Medical Physics
60 Periods
At least 05 experiments from the following:
1. Understanding the working of a manual Hg Blood Pressure monitor, Stethoscope and to 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.


7. Familiarization with Radiation meter and to measure background radiation.

8. Familiarization with the Use of a Vascular Doppler.

Reference Books:
- Christensen’s Physics of Diagnostic Radiology: Curry, Dowdey and Murry - Lippincot Williams and Wilkins (1990)

2nd SEMESTER (Choose any one)

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

This course begins with the review of Vectors and Differential equations and ends with the Special Theory of Relativity. Students will also appreciate the Gravitation, Rotational Motion and Oscillations. The emphasis of this course is to enhance the basics of mechanics. By the end of this course, students should be able to solve the seen or unseen problems/numericals in vectors, differential equations and mechanics.

Vectors: Vector algebra. Derivatives of a vector with respect to a parameter. Scalar and vector products of two, three and four vectors. Gradient, divergence and curl of vectors fields. Polar and Axial vectors. (5 Lectures)
Ordinary Differential Equations: 1st order homogeneous differential equations, exact and non-exact differential equations, 2nd order homogeneous and non-homogenous differential equations with constant coefficients (Operator Method Only). (9 Lectures)


Rotational Dynamics: Angular velocity, Angular momentum, Torque, Conservation of angular momentum, Moment of Inertia. Theorem of parallel and perpendicular axes (statements only). Calculation of Moment of Inertia of discrete and continuous objects (1-D, 2-D and 3-D). Kinetic energy of rotation. Motion involving both translation and rotation. (8 Lectures)

Gravitation: Newton’s Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler’s Laws (statements only). Satellite in circular orbit and applications. Geosynchronous orbits. (4 Lectures)


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.FW Sears, MW Zemansky & HD Young13/e, 1986.Addison-Wesley

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PHYSICS LAB: GE LAB: MECHANICS
60 Periods
At least 05 experiments from the following:
1. Measurements of length (or diameter) using Vernier calliper, 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 the spring and calculate (a) Spring constant and, (b) g.
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.Flinton and H.T.Worsnop, 1971, Asia Publishing House.
- Engineering Practical Physics, S. Panigrahi and B.Mallick, 2015, Cengage Learning India Pvt. Ltd.

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

This course introduces modern development in physics. Starting from Planck’s Law it develops the idea of probability interpretation and then discusses the formulation of Schrodinger equation. It also introduces basic concepts of Nuclear Physics.

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

Problems with Rutherford model- instability of atoms and observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; calculation of energy levels for hydrogen like atoms and their spectra. (6 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. (6 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)

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

GE LAB: ELEMENTS OF MODERN PHYSICS

60 Periods

AT LEAST 05 EXPERIMENTS FROM THE FOLLOWING
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.

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

GE: SOLID STATE PHYSICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

This syllabus gives an introduction to the basic phenomena in Solid State Physics. This aims to provide a general introduction to theoretical and experimental topics in solid state physics. On successful completion of the module students should be able to elucidate the main features of crystal lattices and phonons, understand the elementary lattice dynamics and its influence on the properties of materials, describe the main features of the physics of electrons in solids; explain the dielectric ferroelectric and magnetic properties of solids with their applications and understand the basic concept in superconductivity.


**Applications:** Piezoelectric, Pyroelectric, Ferroelectric, Ferromagnetic materials (3 Lectures)

**Elementary band theory:** Band Gaps. Conductors, Semiconductors and insulators. P and N type Semiconductors. Conductivity of Semiconductors, mobility, Hall Effect, Hall coefficient. (10 Lectures)

**Superconductivity:** Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors. (5 Lectures)

**Reference Books:**
- Introduction to Solid State Physics, Charles Kittel, 8th Ed., 2004, Wiley India Pvt. Ltd.

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**GE LAB: SOLID STATE PHYSICS**

**60 Periods**

**AT LEAST 06 EXPERIMENTS FROM THE FOLLOWING**

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 (up to 150°C) by four-probe method and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.
11. To measure the resistivity of a semiconductor (Ge) with temperature by two-probe method and to determine its band gap.


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

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

_In this course, students will learn about the 8051 I/O port programming, various addressing modes, Timer and counter programming, Serial port programming with and without interrupt and interfacing 8051 microcontroller to peripherals._

**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. *(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 and their functions, I/O port programming in 8051, (Using Assembly Language), I/O programming: Bit manipulation. *(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)

Introduction to Arduino: Pin diagram and description of Arduino UNO. Basic programming and applications. (6 Lectures)

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

PRACTICALS- GE LAB: EMBEDDED SYSTEM: INTRODUCTION TO MICROCONTROLLERS

60 Periods
At least 06 experiments based on 8051 microcontroller from the following:
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 clockwise 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

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PHYSICS-GE: Biological Physics
(Credits: Theory-05, Tutorials-01)

Theory: 75 Lectures

The Biological Physics course introduces the emerging inter-disciplinary field on the interface of Physics and Biology. It makes use of concepts from Physics and discusses their application in Biology. This course helps the students to develop a system level perspective of Biology and equips them with the required mathematical and computational skills.

Overview: (9 Lectures)

Molecules of life: (22 Lectures)
Metabolites, proteins and nucleic acids. Their sizes, types and roles in structures and processes. Transport, energy storage, membrane formation, catalysis, replication, transcription, translation, signaling.
Typical populations of molecules of various types present in cells, their rates of production and turnover. Energy required to make a bacterial cell.
Simplified mathematical models of transcription and translation, small genetic circuits and signaling pathways. Random walks and applications to biology. Mathematical models to be studied analytically and computationally.
The complexity of life: 


At the level of an ecosystem and the biosphere: Foodwebs. Feedback cycles and self-sustaining ecosystems.

Evolution:

The mechanism of evolution: variation at the molecular level, selection at the level of the organism. Models of evolution. The concept of genotype-phenotype map. Examples.

Reference Books:

- Physics in Molecular Biology; Kim Sneppen & Giovanni Zocchi (CUP 2005)
- An Introduction to Systems Biology; Uri Alon (Chapman and Hall/CRC, Special Indian Edition, 2013)
- Evolution; M. Ridley (Blackwell Publishers, 2009, 3rd edition)

3rd SEMESTER (Choose any one)

GE: WAVES AND OPTICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

The physics and mathematics of wave motion underlie many important phenomena. The water wave on the sea, the vibration of a violin string, etc. can all be described in a similar way. Light too, often displays properties that are wave-like. The course is aimed at equipping the students with the general treatment of waves. This begins with explaining ideas of oscillations and simple harmonic motion and go on to look at the physics of travelling and standing waves. This understanding applies to have
a more elaborate analysis for sound waves and this further considers a number of phenomena in which the wave properties of light are important such as interference, diffraction, and polarization with emphasis of examples as seen in daily life.

**Superposition of Two Collinear Harmonic oscillations**: Simple harmonic motion (SHM). Linearity and Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats). (6 Lectures)

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

**Waves Motion- General**: Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity. (8 Lectures)

**Sound**: Sound waves, production and properties. Intensity and loudness of sound. Decibels. Intensity levels. General idea of musical notes and musical scale. Acoustics of buildings (General idea). (6 Lectures)


**Polarization**: Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization (General idea). (7 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
GE LAB: WAVES AND OPTICS

60 Periods

AT LEAST 05 EXPERIMENTS FROM THE FOLLOWING

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 Refractive Index of the Material of a Prism using Sodium Light.

6. To determine Dispersive Power of the Material of a Prism using Mercury Light

7. To determine the value of Cauchy Constants.

8. To determine the Resolving Power of a Prism.


11. To determine the wavelength of Laser light using Diffraction of Single Slit.

12. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating


14. To determine the wavelength of laser light using diffraction grating.

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

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GE: QUANTUM MECHANICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

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

In continuation with modern physics this course is an application of Schrodinger equation to various quantum mechanical problems. This gives fair idea of formulation of eigenvalues and eigen functions.

(10 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 the spread of Gaussian wavepacket for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.

(12 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.

(10 Lectures)

**Quantum theory of hydrogen-like atoms:** time independent Schrodinger 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)


(8 Lectures)


(10 Lectures)

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

60 Periods

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:

\[
\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2} [V(r) - E] \]

where \( V(r) = -\frac{e^2}{r} \)

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

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

\[
\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2} [V(r) - E] \]

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 \( e = 3.795 \text{ (eVÅ)}^{1/2} \), \( m = 0.511 \times 10^6 \text{ eV/c}^2 \), and \( a = 3 \text{ Å}, 5 \text{ Å}, 7 \text{ Å} \). In these units \( \hbar c = 1973 \text{ (eVÅ)} \). 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 \( m \):

\[
\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2} [V(r) - E] \]

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 \( m = 940 \text{ MeV/c}^2 \), \( k = 100 \text{ MeV fm}^2 \), \( b = 0, 10, 30 \text{ MeV fm}^3 \) In these units, \( \hbar c = 197.3 \text{ MeV fm} \). The ground state energy I expected to lie between 90 and 110 MeV for all three cases.

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

\[
\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2\mu}{\hbar^2} [V(r) - E] \]

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

\[
V(r) = D\left(e^{-2ar'} - e^{-ar'}\right), \quad r' = \frac{r - r_o}{r}
\]

\[ 121 \]
Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function. Take: \( m = 940 \times 10^6 \text{eV/C}^2 \), \( D = 0.755501 \text{eV} \), \( \alpha = 1.44 \), \( r_o = 0.131349 \text{Å} \)

**Some laboratory based experiments: (optional)**

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

**Reference Books:**
- Elementary Numerical Analysis, K.E. Atkinson, 3rd Ed. 2007, WileyIndia Edition

**PHYSICS- GE: COMMUNICATION SYSTEM**

(Credits: Theory-04, Practicals-02)

**Theory:** 60 Lectures

*This paper aims to describe the concepts of electronics in communication. Communication techniques based on Analog Modulation, Analog and digital Pulse Modulation including PAM, PWM, PPM, ASK, PSK, FSK are described in detail. Communication and Navigation systems such as GPS and mobile telephony system are introduced.*


(4 Lectures)

**Analog Modulation:** Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Super heterodyne receiver.

(12 Lectures)
Analog Pulse Modulation: Channel capacity, Sampling theorem, Basic Principles-PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing. (9 Lectures)

Digital Pulse Modulation: Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques, Sampling, Quantization and Encoding, Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK). (10 Lectures)

Introduction to Communication and Navigation systems:
Satellite Communication– Introduction, need, Geosynchronous satellite orbits, geostationary satellite advantages of geostationary satellites. Satellite visibility, transponders (C - Band), path loss, ground station, simplified block diagram of earth station. Uplink and downlink. (10 Lectures)

Mobile Telephony System – Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only). GPS navigation system (qualitative idea only) (15 Lectures)

Reference Books:
- Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
- Communication Systems, S. Haykin, 2006, Wiley India
- Wireless communications, Andrea Goldsmith, 2015, Cambridge University Press

PHYSICSS LAB-GE LAB: COMMUNICATION SYSTEM LAB
60 Periods

AT LEAST 05 EXPERIMENTS FROM THE FOLLOWING
1. To design an Amplitude Modulator using Transistor
2. To study envelope detector for demodulation of AM signal
3. To study FM - Generator and Detector circuit
4. To study AM Transmitter and Receiver
To study FM Transmitter and Receiver
To study Time Division Multiplexing (TDM)
To study Pulse Amplitude Modulation (PAM)
To study Pulse Width Modulation (PWM)
To study Pulse Position Modulation (PPM)
To study ASK, PSK and FSK modulators

Reference Books:

PHYSICS-GE: VERILOG AND FPGA BASED SYSTEM DESIGN
(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures
This paper provides a review of combinational and sequential circuits such as multiplexers, demultiplexers, decoders, encoders and adder circuits. Evolution of Programmable logic devices such as PAL, PLA and GAL is explained. At the end of the syllabus, students will be able to understand the modeling of combinational and sequential circuits (including FSM and FSMD) with Verilog Design.


Verilog HDL: Introduction to HDL. Verilog primitive operators and structural Verilog Behavioral Verilog. Design verification. Modeling of combinational and sequential circuits (including FSM and FSMD) with Verilog Design examples in Verilog. (20 lectures)

Reference Books:

PRACTICALS-GE LAB: VERILOG AND FPGA LAB
60 Periods

AT LEAST 08 EXPERIMENTS FROM FOLLOWING.
1. Write code to realize basic and derived logic gates.
2. Half adder, Full Adder using basic and derived gates.
3. Half subtractor and Full Subtractor using basic and derived gates.
5. Multiplexer (4x1) and Demultiplexer using logic gates.
6. Decoder and Encoder using logic gates.
7. Clocked D, JK and T Flip flops (with Reset inputs)
8. 3-bit Ripple counter
9. To design and study switching circuits (LED blink shift)
10. To design traffic light controller.
11. To interface a keyboard
12. To interface a LCD using FPGA
13. To interface multiplexed seven segment display.
14. To interface a stepper motor and DC motor.
15. To interface ADC 0804.

Reference Books
• W.Wolf, FPGA- based System Design, Pearson, 2004
• U. Meyer Baese, Digital Signal Processing with FPGAs, Springer, 2004
• Verilog HDL primer- J. Bhasker. BSP, 2003 II edition

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

This course introduces the essence of nano materials, their synthesis, and characterization. On successful completion of the module students should also be able to understand the optical properties and electron transport phenomenon in nanostructures. It also covers few important applications of nano materials used in this technological era.

NANOSCALE SYSTEMS: Density of states (1-D,2-D,3-D). 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, Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences. (10 Lectures)


ELECTRON TRANSPORT: Carrier transport in nanostructures. Coulomb blockade effect, thermionic emission, tunneling and hopping conductivity. Defects and impurities: Deep level and surface defects. (6 Lectures)


Reference books:
- C.P.Poole, Jr. Frank J.Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
PRACTICALS-GE LAB: Nano Materials and Applications
60 Periods

At least 04 experiments from the following:
1. Synthesis of metal nanoparticles by chemical route.
2. Synthesis of semiconductor nanoparticles.
3. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.
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:
- C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
- Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).

4th SEMESTER (Choose any one)

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

This course will introduce Thermodynamics, Kinetic theory of gases and Statistical Mechanics to the students. The primary goal is to understand the fundamental laws of thermodynamics and its applications to various thermo dynamical systems and processes. This coursework will also enable the students to understand the connection between the macroscopic observations of physical systems and microscopic behaviour of atoms and molecules through statistical mechanics.

**Laws of Thermodynamics:** Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work. Various Thermodynamical Processes, Applications of First Law: General Relation between \( C_p \) and \( C_V \), Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law, Entropy, Carnot’s cycle & theorem, Entropy changes in reversible and irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero. (22 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 equipartition of energy (no derivation) and its applications to specific heat of gases. (10 Lectures)

**Theory of Radiation:** Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck’s law, Deduction of Wien’s law, Rayleigh-Jeans Law, Stefan Boltzmann Law & Wien’s displacement law from Planck’s law. (6 Lectures)


**Reference Books:**
GE LAB: THERMAL PHYSICS & STATISTICAL MECHANICS

60 Periods

AT LEAST 05 EXPERIMENTS FROM THE FOLLOWING

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.

ELECTRONICS-GE: DIGITAL SIGNAL PROCESSING

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

This paper describes the discrete-time signals and systems, Fourier Transform Representation of Aperiodic Discrete-Time Signals. This paper also highlights the concept of filters and realization of Digital Filters. At the end of the syllabus, students will develop the understanding of Discrete and fast Fourier Transform.

and Odd Signals, Discrete-Time Systems, System Properties. Impulse Response, Convolution Sum; Graphical Method; Analytical Method, Properties of Convolution; Commutative; Associative; Distributive; Shift; Sum Property System Response to Periodic Inputs, Relationship Between LTI System Properties and the Impulse Response; Causality; Stability; Invertibility, Unit Step Response.  

**Discrete-Time Fourier Transform:** Fourier Transform Representation of Aperiodic Discrete-Time Signals, Periodicity of DTFT, Properties; Linearity; Time Shifting; Frequency Shifting; Differencing in Time Domain; Differentiation in Frequency Domain; Convolution Property. **The \( z \)-Transform:** Bilateral (Two-Sided) \( z \)-Transform, Inverse \( z \)-Transform, Relationship Between \( z \)-Transform and Discrete-Time Fourier Transform, \( z \)-plane, Region-of-Convergence; Properties of ROC, Properties; Time Reversal; Differentiation in the \( z \)-Domain; Power Series Expansion Method (or Long Division Method); Analysis and Characterization of LTI Systems; Transfer Function and Difference-Equation System. Solving Difference Equations.  

**Filter Concepts:** Phase Delay and Group delay, Zero-Phase Filter, Linear-Phase Filter, Simple FIR Digital Filters, Simple IIR Digital Filters, All pass Filters, Averaging Filters, Notch Filters.  

**Discrete Fourier Transform:** Frequency Domain Sampling (Sampling of DTFT), The Discrete Fourier Transform (DFT) and its Inverse, DFT as a Linear transformation, Properties; Periodicity; Linearity; Circular Time Shifting; Circular Frequency Shifting; Circular Time Reversal; Multiplication Property; Parseval’s Relation, Linear Convolution Using the DFT (Linear Convolution Using Circular Convolution), Circular Convolution as Linear Convolution with aliasing.  

**Fast Fourier Transform:** Direct Computation of the DFT, Symmetry and Periodicity Properties of the Twiddle factor (WN), Radix-2 FFT Algorithms; Decimation-In-Time (DIT) FFT Algorithm; Decimation-In-Frequency (DIF) FFT Algorithm, Inverse DFT Using FFT Algorithms.  

**Realization of Digital Filters:** Non Recursive and Recursive Structures, Canonic and Non Canonic Structures, Equivalent Structures(Transposed Structure), FIR Filter structures;Direct-Form;Cascade-Form;Basic structures for IIR systems;Direct-Form I.  

**Finite Impulse Response Digital Filter:** Advantages and Disadvantages of Digital Filters, Types of Digital Filters: FIR and IIR Filters; Difference Between FIR and IIR Filters, Desirability of Linear-Phase Filters, Frequency Response of Linear-Phase FIR Filters, Impulse Responses of Ideal Filters, Windowing Method; Rectangular; Triangular; Kaiser Window, FIR Digital Differentiators.  

**Infinite Impulse Response Digital Filter:** Design of IIR Filters from Analog Filters, IIR Filter Design by Approximation of Derivatives, Backward Difference Algorithm, Impulse Invariance Method. 

130
Reference Books:
- Digital Signal Processing, Tarun Kumar Rawat, 2015, Oxford University Press, India

PRACTICAL-GE LAB: DIGITAL SIGNAL PROCESSING LAB
60 Periods

At least 06 experiments from the following using Scilab/Matlab. Introduction to Numerical computation software Scilab/Matlab be introduced in the lab.

1. Write a program to generate and plot the following sequences: (a) Unit sample sequence \( \delta(n) \), (b) unit step sequence \( u(n) \), (c) ramp sequence \( r(n) \), (d) real valued exponential sequence \( x(n) = (0.8)^n u(n) \) for \( 0 \leq n \leq 50 \).

2. Write a program to compute the convolution sum of a rectangle signal (or gate function) with itself for \( N = 5 \)
   \[
   x(n) = \text{rect} \left( \frac{n}{2N} \right) = \Pi \left( \frac{n}{2N} \right) = \begin{cases} 1 & -N \leq n \leq N \\ 0 & \text{otherwise} \end{cases}
   \]

3. An LTI system is specified by the difference equation
   \[
   y(n) = 0.8y(n - 1) + x(n)
   \]
   (a) Determine \( H(e^{jw}) \)
   (b) Calculate and plot the steady state response \( y_{ss}(n) \) to
   \[
   x(n) = \cos(0.5\pi n) u(n)
   \]

4. Given a casual system
   \[
   y(n) = 0.9y(n - 1) + x(n)
   \]
   (a) Find \( H(z) \) and sketch its pole-zero plot
   (b) Plot the frequency response \( |H(e^{jw})| \) and \( \angle H(e^{jw}) \)

5. Design a digital filter to eliminate the lower frequency sinusoid of \( x(t) = \sin 7t + \sin 200t \). The sampling frequency is \( f_s = 500 \) Hz. Plot its pole zero diagram, magnitude response, input and output of the filter.
6. Let $x(n)$ be a 4-point sequence:
\[
x(n) = \{1,1,1,1\} \uparrow = \begin{cases} 1 & 0 \leq n \leq 3 \\ 0 & \text{otherwise} \end{cases}
\]
Compute the DTFT $X(e^{j\omega})$ and plot its magnitude
(a) Compute and plot the 4 point DFT of $x(n)$
(b) Compute and plot the 8 point DFT of $x(n)$ (by appending 4 zeros)
(c) Compute and plot the 16 point DFT of $x(n)$ (by appending 12 zeros)

7. Let $x(n)$ and $h(n)$ be the two 4-point sequences,
\[
x(n) = \{1,2,2,1\} \uparrow \\
h(n) = \{1,-1,-1,1\} \uparrow
\]
Write a program to compute their linear convolution using circular convolution.

8. Using a rectangular window, design a FIR low-pass filter with a pass-band gain of unity, cut off frequency of 1000 Hz and working at a sampling frequency of 5 KHz. Take the length of the impulse response as 17.

9. Design an FIR filter to meet the following specifications:
   passband edge $F_p = 2$ KHz
   stopband edge $F_s = 5$ KHz
   Passband attenuation $A_p = 2$ dB
   Stopband attenuation $A_s = 42$ dB
   Sampling frequency $F_s = 20$ KHz

10. The frequency response of a linear phase digital differentiator is given by
\[
H_d(e^{j\omega}) = j\omega e^{-j\tau\omega} \quad |\omega| \leq \pi
\]
Using a Hamming window of length $M = 21$, design a digital FIR differentiator. Plot the amplitude response.

Reference Books:
- Digital Signal Processing, Tarun Kumar Rawat, Oxford University Press, India
- Getting started with MATLAB, Rudra Pratap, 2010, Oxford University Press.
GE: Nuclear and Particle Physics
(Credits: Theory-05, Tutorials-01)

Theory: 75 Lectures

The objective of the course is to impart the understanding of the sub atomic particles and their properties. It will emphasize to gain knowledge about the different nuclear techniques and their applications in different branches of Physics and societal application. The course will focus on the developments of problem based skills. The acquire knowledge can be applied in the areas of nuclear, medical, archeology, geology and other interdisciplinary fields of Physics and Chemistry. It will enhance the special skills required for these fields.

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

**Nuclear Models:** Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, nucleon separation energies (up to two nucleons), Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure and the basic assumption of shell model. (11 Lectures)

**Radioactivity decay:** Decay rate and equilibrium (Secular and Transient)(a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy, decay Chains. (b) β-decay: energy kinematics for β-decay, β-spectrum, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission from the excited state of the nucleus & kinematics, internal conversion. (10 Lectures)

**Nuclear Reactions:** Types of Reactions, units of related physical quantities, 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)

**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. (9 Lectures)

**Detector for Nuclear Radiations:** Gas detectors: estimation of electric field, mobiliyof 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.

Particle Accelerators: Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons (Principal, construction, working, advantages and disadvantages).

Particle physics: Particle interactions (concept of different types of forces), basic features, Cosmic Rays, types of particles and its families, Conservation Laws (energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness) concept of quark model, color quantum number and gluons.

Reference Books:

For Numericals
- Schaum’s Outline of Modern Physics, McGraw-Hill Education, 1999

PHYSICS-GE: Astronomy and Astrophysics
(Credits: Theory-05, Tutorials-01)

Theory: 75 Lectures
The syllabus of "Astronomy and Astrophysics" has been designed in a manner that provides excellent platform for understanding the origin and evolution of the Universe. It gives a comprehensive introduction on the measurement of basic astronomical parameters such as astronomical scales, luminosity and astronomical quantities. This course gives an overview on key developments in observational astrophysics. This primarily includes the telescope optics, instrument detectors and the choice of observation sites. The syllabus also reviews the formation of planetary system and its evolution with time. This course nicely covers the physical properties of Sun and the components of the solar system; and stellar and interstellar components of our Milky Way galaxy. It emphasizes on the physical laws
that enable us to understand the origin and evolution of galaxies, presence of dark matter and large scale structures of the Universe.

**Basic Astronomical Parameters:** Astronomical scales (Distance, Mass and Time), Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus, Measurement of Astronomical Quantities (Distances, Stellar Radii, Masses of Stars from binary orbits, Stellar Temperature, Color index of stars).

**Basic concepts of positional astronomy:** Celestial Sphere, Geometry of a Sphere, Astronomical Coordinate Systems, Horizon System, Equatorial System, Coordinate transformation between Horizon and Equatorial system, Diurnal Motion of the Stars. Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Julian Date.

**Stellar spectra:** Spectral types and their temperature dependence, Hertzsprung-Russell Diagram. (24 Lectures)

**Astronomical telescopes and techniques:** Atmospheric Windows, Optical telescopes, Radio telescope, Telescope mountings, Magnification, Light gathering power, resolving power and diffraction limit, Detection limit of telescope, Modern terrestrial and space telescopes (GMRT, Keck, Chandra, HST) (8 Lectures)

**Stellar structure:** Derivation of Virial Theorem for N bodies, Basic Equations of stellar structure, simple stellar models (Polytropic model, Derivation of the Lane-Emden equation, analytical solutions of the Lane-Emden equation) (14 Lectures)


**Large Scale Structure and Expanding Universe:** Main sequence fitting, Standard candles (Cepheid variables, Supernovae), Cosmic Distance Ladder, Clusters of Galaxies (Virial theorem and Dark Matter), Hubble’s Law (9 Lectures)

**Reference Books:**
- Introductory Astronomy and Astrophysics (Fourth Edition), M. Zeilik and S. A. Gregory
PHYSICS-GE: Atmospheric Physics  
(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

This paper aims to describe the characteristics of earth’s atmosphere and also its dynamics. Atmospheric waves along with the basic concepts of atmospheric Radar and Lidar are discussed in detail.


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, Quasi biennial oscillation, annual and semi-annual oscillations, Mesoscale circulations, The general circulations, Tropical dynamics.

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.

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

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,

(12 Lectures)

Reference Books:
- Fundamental of Atmospheric Physics, M.L Salby; Academic Press, Vol 61, 1996
- An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004

PRACTICALS-GE LAB: Atmospheric Physics  
60 Periods
Scilab/C++ based simulations experiments based on Atmospheric Physics problems like (at least 05 experiments)

1. Numerical Simulation for atmospheric waves using dispersion relations
   (a) Atmospheric gravity waves (AGW)
   (b) Kelvin waves
   (c) Rossby waves and mountain waves

2. Offline and online processing of radar data
   (a) VHF radar,
   (b) X-band radar, and
   (c) UHF radar

3. Offline and online processing of LIDAR data

4. Radiosonde data and its interpretation in terms of atmospheric parameters using vertical profiles in different regions of the globe.

5. Handling of satellite data and plotting of atmospheric parameters using different techniques such as radio occultation technique

6. Time series analysis of temperature using long term data over metropolitan cities in India – an approach to understand the climate change

7. PM 2.5 measurement using compact instruments

8. Field visits to National center for medium range weather forecasting, India meteorological departments, and ARIES Nainital to see onsite radiosonde balloon launch, simulation on computers and radar operations on real time basis.

Reference Books:
PHYSICS-GE: Physics of Earth  
(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.  
   (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: layers, variation of temperature with altitude, adiabatic lapse rate, variation of density and pressure with altitude, cloud formation  
   (d) The Cryosphere: Polar caps and ice sheets. Mountain glaciers, permafrost.

3. **Dynamical Processes:**  
   (18 Lectures)  


Climate:
   i. Earth’s temperature and greenhouse effect.
   ii. Paleoclimate and recent climate changes.
   iii. The Indian monsoon system.

The Biosphere: Water cycle, Carbon cycle. The role of cycles in maintaining a steady state.

4. Evolution: (18 Lectures)
Role of the biosphere in shaping the environment. Future of evolution of the Earth and solar system: Death of the Earth (Probable causes).

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:
- Consider a Spherical Cow: A course in environmental problem solving, John Harte, University Science Books
- IGNOU Study material: PHE 15 Astronomy and Astrophysics Block 2

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