# Scheme of Studies BS Physics

## Fall 2023

Additional Director Academics
University of Chitral

**Department of Physics**

**University of Chitral**

ANNEXURE – A

**Scheme of studies BS Physics 4-year program**

**Name of Degree: BS Physics**

**Eligibility Criteria**: The minimum requirements for admission are at least 45% marks in Intermediate

- ✓ pre engineering, Computer Science, DAE equivalent to F.Sc. examination (additional mathematics course is not required in BS).
- ✓ pre-medical examination (additional Two non-credit hour mathematics course is required in BS).

**Duration:** The minimum duration for completion of BS Physics degree is four years and maximum is seven years.

**Degree Completion Requirements:**

To become eligible for award of BS degree, a student must satisfy the following requirements:

a) Must have studied and passed the prescribed courses, totaling 132 credit hours.

b) Must have earned CGPA (Cumulative Grade Point Average) of at least 2.0 on a scale of 4.0.

**BS Curriculum Design**

The structure of BS Program is proposed to meet the needs of students through theory and practical. The students are expected to learn theoretical and practical understanding of the respective field of Physical science.

- Minimum credit hours shall be 132 for BS programs.
- Each program comprises eight semesters spread over four years.
- This scheme of studies applies to the students enrolled in Fall 2023 semester and onward.
- The following table gives the distribution of credit hours in different domains of knowledge.

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# SCHEME OF STUDIES FOR BS (4-YEAR)

## Semester 1st (1st Year)

| Course title | Course code | Credit Hours | Remarks |
|---|---|---|---|
| Mechanics | PHY-111 | 4(4+0) | Major |
| Lab-I (Mechanics) | PHY-112 | 1(0+1) | Major |
| Functional English | PHY-113 | 3(3+0) | General (Compulsory) |
| Quantitative reasoning I (Calculus-I) | PHY-114 | 3(3+0) | General (Compulsory) |
| Applications of Information and Communication Technologies (ICT) | PHY-115 | 3(2+1) | General (Compulsory) |
| Civics and Community Engagement | PHY-116 | 2(2+0) | General(Compulsory) |
| Pre-Calculus I | PHY-117 | 0 | Only for Pre-medical students |
| Total Credit Hours | | 16(14+2) | |

## Semester 2nd

| Course Title | Course Code | Credit Hours | Remarks |
|---|---|---|---|
| Electricity and Magnetism | PHY-121 | 4(4+0) | Major |
| Heat and Thermodynamics | PHY-122 | 3(3+0) | Major |
| Lab-II (Electricity and Magnetism) | PHY-123 | 1(0+1) | Major |
| Expository Writing | PHY-124 | 3(3+0) | General (Compulsory) |
| Quantitative reasoning II (Calculus-II) | PHY-125 | 3(3+0) | General (Compulsory) |
| Basic Economics | PHY-126 | 2(2+0) | General (Social Sciences) |
| Pre-Calculus II and Analytical geometry | PHY-127 | 0 | Only for Pre-medical students |
| Total | | 16(15+1) | |

## Semester 3rd (2ND YEAR)

| Course Title | Course code | Credit Hours | Remarks |
|---|---|---|---|
| Waves and Oscillations | PHY-231 | 3(3+0) | Major |
| Modern Physics | PHY-232 | 3(3+0) | Major |
| Lab-III (Waves and Oscillations) | PHY-233 | 1(0+1) | Major |
| Islamic studies/Ethics | PHY-234/237 | 2(2+0) | General (Compulsory) |
| Chemistry I | PHY-235 | 3(2+1) | General(Natural Sciences) |
| Linear Algebra | PHY-236 | 3(3+0) | General(Interdisciplinary) |
| Total Credit hours | | 15(13+2) | |

## Semester 4th

| Course Title | Course Code | Credit Hours | Remarks |
|---|---|---|---|
| Optics | PHY-241 | 3(3+0) | Major |
| Lab-IV (Optics) | PHY-242 | 1(0+1) | Major |
| Ideology and Constitution of Pakistan | PHY-243 | 2(2+0) | General(Compulsory) |
| Probability and statistics | PHY-244 | 3(3+0) | General (Interdisciplinary) |
| Entrepreneurship | PHY-245 | 2(2+0) | General(Compulsory) |
| Differential Equations | PHY-246 | 3(3+0) | General (Interdisciplinary) |
| Fables, Wisdom Literature, and Epic | PHY-247 | 2(2+0) | General (Arts and Humanities) |
| Total Credit hours | | 16(15+1) | |

## Semester 5th (3rd Year)

| Course Title | Course Code | Credit Hours | Remarks |
|---|---|---|---|
| Mathematical Method of Physics-I | PHY-351 | 3(3+0) | Major |
| Electromagnetic Theory-I | PHY-352 | 3(3+0) | Major |
| Classical Mechanics | PHY-353 | 3(3+0) | Major |
| Electronics-I | PHY-354 | 3(3+0) | Major |
| Lab-V | PHY-355 | 2(0+2) | Major |
| Research Methodology | PHY-356 | 3(3+0) | General (Interdisciplinary) |
| Total | | 17(15+2) | |

## Semester 6th

| Course Title | Course Code | Credit Hours | Remarks |
|---|---|---|---|
| Mathematical Method of Physics-II | PHY-361 | 3(3+0) | Major |
| Quantum Mechanics-I | PHY-362 | 3(3+0) | Major |
| Electromagnetic Theory –II | PHY-363 | 3(3+0) | Major |
| Electronics-II | PHY-364 | 3(3+0) | Major |
| Statistical Physics | PHY-365 | 3(3+0) | Major |
| Lab-VI | PHY-366 | 2(0+2) | Major |
| Total | | 17(15+2) | |

## Semester 7th (4th year)

| Course Title | Course code | Credit Hours | Remarks |
|---|---|---|---|
| Quantum Mechanics-II | PHY-471 | 3(3+0) | Major |
| Atomic and Molecular Physics | PHY-472 | 3(3+0) | Major |
| Solid State Physics I | PHY-473 | 3(3+0) | Major |
| Nuclear Physics | PHY-474 | 3(3+0) | Major |
| Lab-VII | PHY-475 | 2(0+2) | Major |
| Any one of the followings | | | Elective-I |
| **Environmental Physics** | PHY-476 | 3(3+0) | Elective |
| **Methods of Experimental Physics** | PHY-477 | 3(3+0) | Elective |
| **Computer Simulations in Physics** | PHY-478 | 3(3+0) | Elective |
| Total | | 17(15+2) | |

## Semester 8th

| Course Title | Course code | Credit Hours | Remarks |
|---|---|---|---|
| Solid State Physics II | PHY-481 | 3(3+0) | Major |
| Capstone Project | PHY-482 | 3(3+0) | |
| Field Experience | | 3(3+0) | |
| Any three of the followings | | | Elective-II, Elective-III, Elective-IV |
| **Plasma Physics** | PHY-483 | 3(3+0) | Elective |
| **Electronic Materials and Devices** | PHY-484 | 3(3+0) | Elective |
| **Introduction to Material Science** | PHY-485 | 3(3+0) | Elective |
| **Renewable Sources of Energy** | PHY-486 | 3(3+0) | Elective |
| **Particle Physics** | PHY-487 | 3(3+0) | Elective |
| **Introduction to Nano Science & Nanotechnologies** | PHY-488 | 3(3+0) | Elective |
| **Laser Applications** | PHY-489 | 3(3+0) | Elective |
| Total | | 18(18+0) | |

## Summary of courses

### Major courses

| | | | |
|---|---|---|---|
| Mechanics | PHY-111 | 4(4+0) | Major |
| Lab-I (Mechanics) | PHY-112 | 1(0+1) | Major |
| Electricity and Magnetism | PHY-121 | 4(4+0) | Major |
| Heat and Thermodynamics | PHY-122 | 3(3+0) | Major |
| Lab-II (Electricity and Magnetism) | PHY-123 | 1(0+1) | Major |
| Waves and Oscillations | PHY-231 | 3(3+0) | Major |
| Modern Physics | PHY-232 | 3(3+0) | Major |
| Lab-III (Waves and Oscillations) | PHY-233 | 1(0+1) | Major |
| Optics | PHY-241 | 3(3+0) | Major |
| Lab-IV (Optics) | PHY-242 | 1(0+1) | Major |
| Mathematical Method of Physics-I | PHY-351 | 3(3+0) | Major |
| Electromagnetic Theory-I | PHY-352 | 3(3+0) | Major |
| Classical Mechanics | PHY-353 | 3(3+0) | Major |
| Electronics-I | PHY-354 | 3(3+0) | Major |
| Lab-V | PHY-355 | 2(0+2) | Major |
| Mathematical Method of Physics-II | PHY-361 | 3(3+0) | Major |
| Quantum Mechanics-I | PHY-362 | 3(3+0) | Major |
| Electromagnetic Theory –II | PHY-363 | 3(3+0) | Major |
| Electronics-II | PHY-364 | 3(3+0) | Major |
| Statistical Physics | PHY-365 | 3(3+0) | Major |
| Lab-VI | PHY-366 | 2(0+2) | Major |
| Quantum Mechanics-II | PHY-471 | 3(3+0) | Major |
| Atomic and Molecular Physics | PHY-472 | 3(3+0) | Major |
| Solid State Physics I | PHY-473 | 3(3+0) | Major |
| Nuclear Physics | PHY-474 | 3(3+0) | Major |
| Lab-VII | PHY-475 | 2(0+2) | Major |
| Solid State Physics II | PHY-481 | 3(3+0) | Major |
| **Total Cr. Hrs** | | 72(65+7) | |

## Elective Courses

Four Elective courses =12 Cr. Hrs

General Courses

| Course title | Course code | Credit Hours | Remarks |
|---|---|---|---|
| Functional English | PHY-113 | 3(3+0) | General (Compulsory) |
| Calculus-I (quantitative reasoning I) | PHY-114 | 3(3+0) | General (Compulsory) |
| Applications of Information and Communication Technologies (ICT) | PHY-115 | 3(2+1) | General (Compulsory) |
| | | | |
| Civics and Community Engagement | PHY-117 | 2(2+0) | General(Compulsory) |
| Expository Writing | PHY-124 | 3(3+0) | General (Compulsory) |
| Calculus-II(quantitative reasoning II) | PHY-125 | 3(3+0) | General (Compulsory) |
| Basic Economics | PHY-126 | 2(2+0) | General (Social Sciences) |
| Islamic studies | PHY-234 | 2(2+0) | General (Compulsory) |
| Chemistry I | PHY-235 | 3(2+1) | General(Natural Sciences) |
| Fables, Wisdom Literature, and Epic | PHY-237 | 2(2+0) | General (Arts and Humanities) |
| Ideology and Constitution of Pakistan | PHY-243 | 2(2+0) | General(Compulsory) |
| Entrepreneurship | PHY-245 | 2(2+0) | General(Compulsory) |
| Total | | 30 | |

Interdisciplinary Courses

| | | | |
|---|---|---|---|
| Linear Algebra | PHY-237 | 3(3+0) | General(Interdisciplinary) |
| Probability and statistics | PHY-244 | 3(3+0) | General (Interdisciplinary) |
| Differential Equations | PHY-246 | 3(3+0) | General (Interdisciplinary) |
| Research Methodology | PHY-356 | 3(3+0) | General (Interdisciplinary) |
| Total Cr. Hrs | | 12 | |

Capstone Project;

Cr. Hrs =3

Field Experience

Cr. Hrs = 3

**Total Credit Hours: 132**

## RECOMMENDED COURSES FOR BS PHYSICS

### PHY-111 MECHANICS

**Credit Hours:** Four (4)

**Objectives:** The main objective of this course is to understand different motions of objects on macroscopic scale and to develop simple mathematical formalisms to analyze such motions. This is a calculus-based introductory course with maximum emphasis on applying the acquired knowledge to solving problems.

**Basic Concepts:** Units and Dimensions, SI Units, Inter-conversion of Units; Scalars and Vectors, Adding Vectors: Graphical as well as Component Method, Multiplying Vectors: Dot and Cross Products.

**Motion in One, Two and Three Dimensions:** Position & Displacement; Velocity and Acceleration; Motion under Constant Acceleration; Projectile Motion; Uniform Circular Motion; Relative Velocity and Acceleration in One and Two Dimensions; Inertial and Non-Inertial Reference Frames

**Newton's Laws:** Newton's Laws of Motion and their Applications Involving some Particular Forces including Weight; Normal Force; Tension; Friction; and Centripetal Force; Newton's Law of Gravitation; Gravitational Potential Energy; Escape Velocity; Kepler's Laws; Satellite Orbits & Energy

**Work and Kinetic Energy:** Work done by Constant and Variable Forces; Gravitational and Spring Forces; Power; Conservative and Non-conservative Forces; Work and Potential Energy; Isolated Systems and Conservation of Mechanical Energy; Work done by External Forces including Friction, Conservation of Energy

**System of Particles:** Motion of a System of Particles and Extended Rigid Bodies; Center of Mass and Newton's Laws for a System of Particles; Linear Momentum; Impulse; Momentum & Kinetic Energy in One and Two Dimensional Elastic and Inelastic Collisions

**Rotational Motion:** Rotation about a Fixed Axis; Angular Position; Angular Displacement; Angular Velocity and Angular Acceleration; Rotation under Constant Angular Acceleration; relationship between Linear and Angular Variables; Rotational Inertia; Parallel-axis Theorem; Torque and Newton's Law for Rotation; Work and Rotational Kinetic Energy; Power; Rolling Motion; Angular Momentum for a single Particle and a System of Particles; Conservation of Angular Momentum; Precession of a Gyroscope; Static Equilibrium involving Forces and Torques; Rotational inertia of various shapes i.e. for a disc, bar and solid sphere; Elasticity; Stress; Strain and Properties of Materials

**Angular Momentum:** Angular Velocity; Conservation of angular momentum; effect of Torque and its relation with angular momentum

**Simple Harmonic Motion (SHM):** Amplitude; Phase; Angular Frequency; Velocity and Acceleration in SHM; Linear and Angular Simple Harmonic Oscillators; Energy in SHM; Simple Pendulum; Physical Pendulum; SHM and Uniform Circular Motion.

**Fluid Mechanics:** Static Fluids and Pressure; Archimedes' Principle; Fluid Dynamics; Equation of Continuity and Bernoulli's Principle

**Recommended Books:**

1. D. Halliday, R. Resnick and J. Walker, "Fundamentals of Physics", John Wiley & Sons, 9th ed. (2010).

2 R. A. Serway and J. W. Jewett, "Physics for Scientists and Engineers", Golden Sunburst Series, 8th ed. (2010).

3. R. A. Freedman, H. D. Young, and A. L. Ford (Sears and Zeemansky), "University Physics with Modern Physics", Addison-Wesley-Longman, 13th International ed. (2010).

4. F. J Keller, W. E. Gettys and M. J. Skove, "Physics: Classical and Modern, McGraw Hill, 2nd ed. (1992).

5. D. C. Giancoli, "Physics for Scientists and Engineers, with Modern Physics", Addison-Wesley, 4th ed., (2008).

**PHY- 112 Lab-I (Mechanics)**

**Credit Hours:** One (1)

**Mechanics and Fluids:** Experiments with pendulums, stop watches, one-dimensional motion and verification of Newton's laws of motion, measurement of forces, speed, acceleration and linear momentum, collisions and conservation of momentum, impacts, free fall and acceleration due to gravity, gyroscopes, rotational motion, conservation of angular momentum, friction, static and dynamic equilibrium, compound pendulum, rolling motion along inclined planes, simple harmonic motion, masses attached to springs and Hooke's law, damped motion and the regimes of damping (over-damped, under-damped and critically damped), pressure in fluids, experiments demonstrating continuity, Bernoulli's principle, buoyancy and Archimedes's principle, Atwood machine, fluid viscosity, surface tension

**Recommended Books:**

1. A. C. Melissinos and J. Napolitano, "Experiments in Modern Physics", Academic Press, 2nd ed. (2003).
2. J. H. Moore, C. C. Davis, M. A. Coplan, and S. C. Greer, "Building Scientific Apparatus", Cambridge University Press, 4th ed. (2009).
3. J. R. Taylor, "An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements", University of Science Books, 2nd ed. (1996).
4. L. Kirkup and R. B. Frenkel, "An Introduction to Uncertainty in Measurement", Cambridge University Press, (2006).
5. G. L. Squires, "Practical Physics", Cambridge University Press, 4th ed. (2001).
6. Y. Tsividis, "A First Lab in Circuits and Electronics", John Wiley (2001).

**PHY-113 Functional English**

**Credit Hours:** Three (3)

## *COURSE DISCRIPTION*

The purpose of this course is to develop the English-language proficiency of students and to help them become confident in reading, writing, speaking, and listening to the English language. Instead of teaching grammar in isolation and only at sentence level, this course is based on developing the language abilities of students through an integrated approach that provides opportunities to develop their listening, speaking, reading, and writing skills. With a focus on social interaction, the course draws specific attention to the accurate use of structures, improvement of pronunciation, and development of active vocabulary in descriptive, narrative, and instructional texts.

## *COURSE OUTCOMES*

After completing this course, students will:

- have improved their listening and reading skills in English
- be able to communicate in written and oral English with peers and teachers
- rely less on their first languages and increase their use of English in formal and informal situations
- have a deeper understanding of correct English structures in descriptive, narrative, and instructional texts.

## *COURSE CONTENTS*

**Basics of Grammar**

- Parts of Speech and their Usage
- Sentence and Its Structure
- Phrase, usage of phrases
- Clause, usage of clauses

## Introductions

This first unit will provide students with an opportunity to interact with one another in oral and written forms. It will serve to introduce them and help them develop conversations through suggesting simple words and phrases to describe people, preferences, and other conversation topics in a logical sequence.

### Making Introductions

- Making effective self and peer introductions
- Taking useful introductory notes

### Expressing Requests and Enquiries

- Forming appropriate requests and enquiries
- Responding to enquiries
- Requests versus commands

## Social Interaction

This unit is aimed at developing students' social interaction in English and expanding their interpersonal skills. Through class activities, they actively converse in formal and informal contexts to congratulate, express gratitude, make invitations, and respond to speakers in oral and written contexts.

### Greetings

- Greeting friends and family on different occasions and for different reasons
- Responding to a positive event
- Using formal greeting expressions appropriately

### Gratitude

- Using formal and informal expressions of gratitude appropriately
- Reading a story that uses expressions of gratitude
- Writing a formal letter to say thanks to a teacher, parent, or friend

**Invitations**

- Demonstrating the use of formal and informal expressions of invitation
- Developing verbal and written skills for invitations
- Responding to invitation requests by accepting or declining

### Regrets

- Expressing regrets orally and in writing appropriately
- Saying sorry and accepting apologies

## Giving and Following Directions

In this unit, students learn how to follow directions from a map as well as how to give directions to search for a location or specific information. They learn how to follow and provide clear instructions.

### Following and Giving Directions

- Following directions from a map
- Giving directions to a location in oral and written forms
- Reaching a destination

### Giving Clear Instructions

- Carrying out instructions
- Structuring instructions

- Writing clear instructions

### Sharing experiences

In this unit, students will engage with different meanings in a variety of written and visual texts through shared, guided, and independent readings of narratives in various genres. Instructors will encourage them to respond to the narrative and imaginative texts by composing stories and sharing them in written and oral form.

#### Sharing narratives

- Reading short stories
- Reading excerpts, comic strips, interviews, and other common texts

#### Sharing unique experiences

- Summarizing and narrating true stories
- Solving word puzzles to develop language awareness
- Reading short stories and completing exercises to test comprehension
- Converting an event into a short story
- Using pictures as stimuli for narrative creation
- Using songs as examples of personal experience

#### Imaginative texts

- Developing imaginative texts by communicating engrossing stories and descriptions of scenes

### Discussion

General topics and every-day conversation (topics for discussion to be at the discretion of the teacher keeping in view the level of students)

### Composition and Comprehension

#### Writing Mechanics

- Sentences, sentence fragments, and run-on sentences
- Subject-predicate and pronoun-reference agreement
- Punctuation and structure

**Paragraph Writing (practice)**

**Essay Writing (practice)**

**Précis writing (practice)**

## *TEXTBOOKS AND REFERENCES*


- T. K. Carver and S. Fortinos-Riggs, Conversation Book II – English in Everyday Life (New York: Pearson Education Limited, 2006).
- J. Eastwood, Oxford Practice Grammar (Karachi: Oxford University Press, 2005).
- J. Swan, Practical English Usage, 3rd ed. (New York: Oxford University Press, 2005).
- J. Thomson and A. V. Martinet, A Practical English Grammar (Intermediate) (New York: Oxford University Press, 1986)
- Allama Iqbal Open University, Compulsory English 1 (Code 1423) (Islamabad: AIOU Press).
- BBC. (2013) Learning English. http://www.bbc.co.uk/worldservice/learningenglish/
- British Council. Learn English. http://learnenglish.britishcouncil.org/en/
- British Council and BBC. Learn English. http://www.teachingenglish.org.uk/
- Grammar English. http://freesoftwarepc.biz/educational-software/ download-

**PHY- 114 Quantitative Reasoning (CALCULUS-I)**

**(Calculus for Functions of one variable)**

**Credit Hours:** Three (3)

Functions and graphs (shifting and stretching), limits and continuity, differentiation (rates of change, slope of the tangent to a curve, rules for differentiation, chain rule, implicit differentiation, extrema of functions, mean value theorem, use of derivatives in sketching, asymptotic behavior of functions, L'H'opital's rule), integration (indefinite integrals, techniques of integration, Riemann sums and definite integrals, physical interpretation as areas, mean value theorem, areas between curves, finding volumes by slicing, arc lengths, centres of mass and higher moments, work), differentiation and integration of transcendental functions (exponential and logarithmic functions and applications to growth and decay problems, trigonometric and inverse trigonometric functions, hyperbolic functions), infinite series (series, tests of convergence, power series, Taylor and Maclaurin series).

**Recommended Books:**

1. G. B. Thomas, R. L. Finney, "Calculus and Analytic Geometry", National Book Foundation, 9th ed. (1995)
2. G. Strang, "Calculus", Wellesley-Cambridge, 2nd ed., (2010).
3. E. W. Swokowski, M. Olinick, D. Pence, and J. A. Cole, "Calculus"; Pws Pub Co; 6th ed. (1994).

**PHY-115** Applications of Information and Communication Technologies (ICT)

**Credit Hours:** Three (3)

**Week 01: Basic of Computers**

- Introduction and history of computers
- Types of computers (analog, digital, hybrid)
- Block diagram of Computer System.

**Week 02, 03: Parts of the Computer System**

- Hardware (Essential Computer Hardware (Processor, Memory, Input Devices, Output Devices & Storage devices)
- Memory and types
- Primary/Internal memory (RAM & ROM)
- Units of Computer Memory (Bit, Byte, KB, MB, GB, TB)
- Secondary Storage
- Input Devices & Output device

**Week 04, 05: Software**

- System software
- Application software
- General purpose and Special purpose Software

**Week 06: Data Communication and Data Communication System (DCS)**

- Components of DCS (Sender, Receiver, medium, Message & Protocol)

**Week 07: The Internet & Internet Services**

- Electronic mail
- Chat, Online Services
- Web Browsers, URL, Web Searching/ Browsing, Search Engine

**Week 08, 09: Operating Systems**

- Introduction to Windows 10 & Installation
- Working with the Windows 10 Desktop

**Week 10,11,12: Microsoft Word**

- Creating and Modifying a Flyer
- Creating CV and Resume
- Creating a Research Paper

**Week 13: Microsoft PowerPoint**

- Creating and Editing Presentations with Pictures
- Enhancing Presentations with Shapes and SmartArt

**Week 14, 15: Microsoft Excel**

- Creating a Worksheet and a Chart
- Formulas, Functions, and Formatting

**Week 16: Use of computer in daily life**

- Computer as a teacher
- Online education (Example: Virtual University of Pakistan)

Lab: Practicals related to the topics mentioned above like, creating presentation in PPT, composing assignments in MS Word, MS Excel- Creating worksheet etc

**Text Books/Reference Books**

1. Introduction to Computers by Peter Norton, 6th International Edition, McGraw-Hill

2. Using Information Technology: A Practical Introduction to Computer & Communications by Williams Sawyer, 6th Edition, McGraw-Hill

3. Computers, Communications & information: A user's introduction by Sarah E. Hutchinson, Stacey C. Sawyer

4. Fundamentals of Information Technology by Alexis Leon, Mathews Leon, Leon Press.

**PHY-116 Course Name: Civic and Community Engagement**

## Credit Hours: 2(2+0)

## Description

Teach students the importance and role of active citizenship in promoting a productive, Harmonious and development society/ world. Educate students about the importance of Concepts, skills and philosophy of community linkages in developing a sustainable society. Inculcate the importance of community involvement for ensuring an improved, tolerant and Generative society/ world. Provide an opportunity to the students to develop their relationship with the community.

The course is designed to be students' introduction to civic engagement and what it means to be responsible, socially conscious citizens of Pakistan and the world. Students learn the broad definition of civic engagement and critically examine key concepts related to civic and community engagement, including identity and social location, community, and systems of power. As a community-based learning course, students not only discuss these concepts in class but also experience and apply them in real world situations through community engagement experiences—direct service, attending events, exploring social issues, etc. The course provides ample opportunities to reflect on course concepts and engagement experiences, plus students will learn how to advance their knowledge and practice of these concepts beyond the course.

**The Learning Outcomes of the course say that students will be able to:**

- Define civic engagement and community engagement and key concepts such as identity, community, and systems of power.
- Practice skills related to civic engagement (self-awareness, relationship building, dialogue, reflection, etc.) in real-world situations through direct community engagement.
- Identify social issues connected to community engagement experiences, and be able to identify and critically examine additional social issues in class.
- Envision their own identity as an active, engaged, responsible citizen.
- Recognize how effective individual actions can affect social change.
- Identify examples of power and privilege and be able to explain their impact in everyday life.

## Contents

- Introduction to citizenship education and Community Engagement
- Civic Engagement and Community Engagement

a. Identity
b. Community
c. System of Power
d. Culture
e. Social Harmony

- Practice skills related to civic engagement

a. Self-awareness
b. Relationship building
c. Dialogue
d. Reflection

- Social issues in Pakistan

a. Poverty
b. Discrimination
c. Domestic violence
d. Hate speech
e. Intolerance

f. Unemployment
g. Violence
h. Overpopulation
i. Favoritism
j. Other
k. Identification of social issues connected to community engagement experiences.

- Social Action Project

a. Volunteerism
b. Community service
c. Public service
d. Political activism
e. Public service leadership

- Civic Collaboration

a. Multi-cultural society and inter-cultural dialogue
b. Active Citizen: Locally Active, Globally Connected

- Human rights, constitutionalism, and citizens' responsibilities.

**Recommended Books**

1. John J. Macionis, Lindaa Marie Gerber, Sociology (New York: Pearson Education, 2010)
2. Community Development, Social Action and Social Planning by Alan Twelvetrees 12 May 2017
3. The Constitution of the Islamic Republic of Pakistan (Pakistan: The National Assembly of Pakistan,2012),also available online at the official website of National Assembly of Pakistan: http://na.gov.pk/uploads/documents/13333523681 951.pdf(Accessed on April 25, 2017)

**PHY- 117 Pre-Calculus I (Cr Hr 00)**

For BS Physics

**Functions**: Differentiate between relation and function, Domain and range of a function, types of function, graphical representation of function, composition of function, inverse of function, limits of function, continuous and discontinuous function,

**Differentiation**: Independent and dependent variable, concept of rate of change, average and instantaneous rate of change, differentiation by first principle rule, theorem on differentiation, extended power rule and chain rule, differentiation of trigonometric functions, differentiation of exponential and logarithmic function, higher order derivative, application of differentiation,

**Integration**: Introduction, indefinite integrals, rule of integration, integration by substitution, integration by parts, integration by partial fraction, definite integrals, application of integration

**Recommanded books:**

1-Calculus and analytical geometry 9th edition (G.B Thomas, R.L Finney)

2- G.Strang, calculus Wellesley Cambridge 2nd edition (2010)

**PHY-121 ELECTRICITY & MAGNETISM**

**Pre-requisite:** Mechanics

**Credit Hours:** Four (4)

**Objectives:** The main objective of this course is to understand the Physics of Electromagnetism and to develop simple mathematical formalisms to analyze the electromagnetic fields. This is calculus based introductory course with maximum emphasis on applying the acquired knowledge to solve problems.

**Electrostatics:** Electric Charge; Conductors and Insulators; Coulomb's Law; Electric Fields due to a Point Charge and an Electric Dipole; Electric Field due to Charge Distribution; Electric Dipole in an Electric Field; Electric Flux; Gauss' Law and its Applications in Planar; Spherical and Cylindrical Symmetry

**Electric Potential:** Equipotential Surfaces; Potential due to a Point Charge and a Group of Point Charges; Potential due to an Electric Dipole; Potential due to Charge Distribution; Relation between Electric Field and Electric Potential Energy

**Capacitors and Capacitance:** Parallel Plate; Cylindrical and Spherical capacitors; Capacitors in Series and Parallel; Energy Stored in an Electric Field; Dielectrics and Gauss' Law

**DC Circuits:** Electric Current and Current Density; Resistance and Resistivity; Ohm's Law; Power in Electric Circuits; Semiconductors and Superconductors; Work; Energy and EMF; Resistances in Series and Parallel; Single and Multi-loop Circuits; Kirchhoff's Rules; RC Circuits; Charging and Discharging of a Capacitor

**Magnetic Field and Magnetic Force:** Sources of Magnetic Field; Magnetic Force on a Moving Charge; Crossed Electric and Magnetic Fields and their Applications; Hall Effect; Magnetic Force on a Current Carrying Wire; Torque on a Current Loop; Magnetic Dipole Moment; Magnetic Field Due to a Current; Force between two Parallel Currents; Biot-Savart Law: Magnetic Field due to a Current, Long Straight Wire, Solenoids and Toroids, Ampere's Law; A Current-carrying Coil as a Magnetic Dipole; Inductance; Faraday's Law of Induction; Lenz's Law; Induction and Energy Transfer; Induced Electric Fields; Inductors and Inductance; Self Inductance; RL Circuits; Energy Stored in a Magnetic Field; Energy Density; Mutual Induction

**Alternating Fields and Currents:** LC Oscillations; Damped Oscillations in an RLC circuit; Alternating Currents; Forced Oscillations; Resistive, Capacitive, and Inductive Loads; RLC series Circuit; Power in AC Circuits; Transformers; Gauss' Law for Magnetism; Induced Magnetic Fields; Displacement Current; Spin & Orbital Magnetic Dipole Moment; Diamagnetism; Paramagnetism; Ferromagnetism and Hysteresis.

**Recommended Text Books:**

1. D. Halliday, R. Resnick and J. Walker, "Fundamentals of Physics", John Wiley & Sons, 9th ed. (2010).

2. R. A. Serway and J. W. Jewett, "Physics for Scientists and Engineers", Golden Sunburst Series, 8th ed., (2010).

3. R. A. Freedman, H. D. Young, and A. L. Ford (Sears and Zeemansky), "University Physics with Modern Physics", Addison-Wesley-Longman, 13th International ed., (2010).

4. F. J Keller, W. E. Gettys and M. J. Skove, "Physics: Classical and Modern", McGraw Hill, 2nd ed., (1992).

5. D. C. Giancoli, "Physics for Scientists an Engineers, with Modern Physics", Addison-Wesley, 4th ed., (2008).

**PHY-122 HEAT AND THERMODYNAMICS**

**Pre-requisites:** Mechanics

**Credit Hours:** Four (4)

**Objective(s):**To understand the fundamentals of heat and thermodynamics

**Basic Concepts of Thermodynamics:** Thermodynamic Systems; Surrounding and Boundaries; Type of Systems; Macroscopic and Microscopic description of System; Properties and State of the substance; Extensive and Intensive variables; Equilibrium, Mechanical and Thermal Equilibrium; Processes and Cycles (Isothermal, Isobaric Isochoric and adiabatic); Zeroth Law of Thermodynamics; Consequence of Zeroth law of Thermodynamics; Criteria of thermo- dynamical equilibrium.

**Heat and Temperature:** Heat and Work; Unit of work; Work Done at the Moving Boundary of a Simple Compressible System; Heat Transfer Mechanisms; Thermometers; Temperature and the Statistical definition of Temperature; Kinetic theory of Ideal gas; Work done on an Ideal gas; Internal energy of an Ideal gas; Equipartition of Energy; Intermolecular forces; The Virial expansion; The Van der Waals equation of state.

**Thermodynamics:** First law of thermodynamics and its applications to adiabatic, isothermal, cyclic and free expansion; Reversible and irreversible processes; Second law of thermodynamics; Carnot theorem and Carnot engine; Heat engine; Refrigerators; Calculation of efficiency of heat engines; Thermodynamic temperature scale, Absolute zero, Entropy, Entropy in reversible process; Entropy in irreversible process; Entropy and second law of thermodynamics; Entropy and Probability; Thermodynamic potentials; Maxwell's relations; TdS equations, Energy equations and their applications; Intrinsic and mutual stabilities of single component system; Conditions of stabilities; The Lech-atelier Braun Principle; First order Phase transition; Discontinuities of Volume and Entropy; Second Order Phase Transition; Low Temperature Physics; Joule-Thomson effect and its equations; Thermoelectricity; Thermocouple, Seebeck's effect; Peltier's effect; Thomson effect.

**Introduction to Statistical Mechanics:** Statistical distribution and mean values; Mean free path and microscopic calculations of mean free path; Distribution of Molecular Speeds; Distribution of Energies; Maxwell distribution; Maxwell Boltzmann energy distribution; Internal energy of an ideal gas; Brownian Motion Langevin equation,

**Recommended Books:**

1. M. W. Zemansky, "Heat and Thermodynamics", Mc Graw Hill, 7th ed. (1997).
2. M. Sprackling, "Thermal Physics" McMillan (1991).
3. B. N. Roy, "Principle of Modern Thermodynamics", Institute of Physics, London (1995).
4. D. Halliday, R. Resnick and K. Krane, "Physics", John Wiley, 5th ed. (2002).
5. D. Halliday, R. Resnick and J. Walker, "Fundamentals of Physics", John Wiley, 9th ed. (2010).

**PHY- 123 Lab-II (Electricity & Magnetism)**

**Credit Hours:**One (1)

**Electricity and Magnetism:** Static charge and electric fields, direct and alternating currents, electrical measurement instrumentation (voltmeters, ammeters, power supplies, variable transformers, cathode ray oscilloscope, electrometer), passive electronic components (resistors, capacitors, inductors), measurement of resistance, capacitance and inductance, electromagnetic induction, inductors and transformers, motors, magnetic fields due to currents and permanent magnets, ferromagnetism and ferroelectricity, determination of hysteresis curves, determination of Curie point, magnetic susceptibility and its temperature dependence, dielectric properties measurement, mapping of magnetic fields using Hall sensors, experiments on noise, properties of the light bulb.

**Recommended Books:**

1. A. C. Melissinos and J. Napolitano, “Experiments in Modern Physics”, Academic Press, 2nd ed. (2003).
2. J. H. Moore, C. C. Davis, M. A. Coplan, and S. C. Greer, "Building Scientific Apparatus", Cambridge University Press, 4th ed. (2009).
3. J. R. Taylor, "An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements", University of Science Books, 2nd ed. (1996).
4. L. Kirkup and R. B. Frenkel, “An Introduction to Uncertainty in Measurement”, Cambridge University Press, (2006).
5. G. L. Squires, "Practical Physics", Cambridge University Press, 4th ed. (2001).
6. Y. Tsividis, "A First Lab in Circuits and Electronics", John Wiley (2001).

**PHY-124 Course Name: Expository Writing**
**Credit Hours: 3**

*Introduction to Expository Writing*

## COURSE DESCRIPTION

This course prepares undergraduates to become successful writers and readers of English. The coursehelps students develop their fundamental language skills with a focus on writing so that they can gainthe confidence to communicate in oral and written English outside the classroom. The

course is divided into five units and takes a PBL (Project-based Learning) approach. Unit themes target the development of 21st century skills and focus on self-reflection and active community engagement. Course activities include lectures, group, pair and individual activities, as well as a series of required assignments, including reading and writing across various genres. Finally, the course prepares students for taking the next course in the sequence, ‘Expository Writing II: Cross-cultural Communication and Translation Skills’.

## COURSE OBJECTIVES

At the end of the course, the students will be able to:

1. Analyze basic communication skills and use them effectively in oral and written English
2. Develop skills as reflective and self-directed learners
3. Critically evaluate and review various types of texts and summarize them
4. Develop analytical and problem-solving skills to address various community-specific challenges
5. Intellectually engage with different stages of the writing process, such as: brainstorming, mindmapping, free writing, drafting and revision, etc.

## LEARNING OUTCOMES

By the end of this course, the students will be able to

1. Write, edit and proofread a short essay in English language
2. Present ideas to the whole class in team presentations using English that is comprehensible andengaging.
3. Critically analyze a text written in English using SQW3R strategies
4. Conduct small-scale research about their communities
5. Draft a letter to editor.

## Course Outline

**1. Unit 1: Self Reflection**

Introduction to the basics of the writing process, Introduction to the steps of essay writing,

Students practice prewriting activities like brainstorming, listing, clustering and free writing,Students practice outlining of the essay

2. **Unit 2: Personalized Learning**
Students reflect on their learning process. Group discussion about learning styles based on the reading material provided to students Introduction to personalized learning Students practice goal setting and create a learning plan

3. **Introduction to the structure and significance of oral presentations**
Introduction to the structure and significance of oral presentations

Class discussion about content selection and slide preparation for oral presentationsPeer review through a gallery walk

4. **Unit 3: Critical Reading Skills**
Introduce authentic reading (DAWN newspaper and non-specialist academic books/texts Conduct classroom reading activities (using strategies skimming, scanning, SQW3R, previewing, annotating, detailed reading and note-taking) using standard tests (TOEFL andIELTS)

Assign books/articles/reports for their individual home assignments Share model review reports and annotated bibliographies

5. **Unit 4: Community Engagement**
Showing short documentaries to students on global environmental issuesStudent-led brainstorming on local versus global issues

Teacher-led introduction to the unit assignment (using assignment sheet)

Readings (or other input sources - video, social media) from local news on possiblecommunity issues, letters to editor and op-eds

Identify research problems

Begin drafting research questions based on the problems identified Facilitating students on developing research questions in groups

Draft interview or survey questions for community research (in English or L1) In-class role-plays of interviews with community members

Engaging students in critical reading and reflection on the issues found in differentcommunities

In-class work on understanding interview information, how to present interview or surveyinformation

Refining the research questions, designing a detailed research plan in groups, dividing thetasks and deciding the timeline for the completion of the project

Exposure to interview questions and interviewing techniques to develop an in-depthunderstanding of the issues

Continued group work on report outline In-class lecture and group work on analyzinginformation

Discussion based on translating the data from the source language to the target language(English)

Sharing the experience of field work in class orally

**Mid Term**

Teacher feedback on outline of report (globally to entire class and individually to groups asneeded)

Think-pair-share the findings (group similar issues)

Individual writing of reflection on the community engagement project and their role in thegroup

Brainstorm using creativity for dissemination - cartoons, advertisements for universitymagazine or beyond, creating posts for FB

Summarizing/ converting the report to a letter to the editor to highlight the

6. **Unit 5: Letter to the Editor**

Teacher-directed instruction on genres (types) of writing focusing on letter-writing

Model-practice-reflect: Introduce types of letters comparing the use of formal and informalvocabulary and phrases in each type

Introduce the format and purpose of the letter-to-editor explaining with the help of an actualletter from a local newspaper

Group reading of sample letters-to-editor selecting ones that deal with issues familiar to thestudents

Invite a guest lecturer (local newspaper editor or faculty from journalism) to talk about whatissues are currently raised in letters-to-editors and what are editors' criteria to accept lettersfor publication

Work in groups to continue reviewing letter samples, analyzing the structure of letters

Each group identifies an issue they want to write about and give a brief oral presentation tothe class

Submit the first draft of letters (to the teacher and peer-review group)

In-class peer review of drafts using a checklist focusing on content and structureDUE: First draft f letter (to teacher and peer review group)

Groups revise first draft of letter

Differentiate among revision, proofreading and evaluation (as sub stages of finalizingdocuments)

Discuss critically the draft-letter and implement the 'revision' phase of writing

Reading of (DAWN) newspaper and sharing important letters (to editors) on local issuesGroups revise second draft of letter

Explicit instruction (paragraph structure, syntax, diction, grammar, and mechanics)Classroom discussion/debrief of activity

Discuss critically and finalize the draft-letter as the last phase of writing

## *Essential Reading*

Organizing an Essay,Accessed at:

https://courses.lumenlearning.com/englishcomp1v2xmaster/chapter/organizing-an-essay/ Learning Preferences and Strengths

Accessed at:

https://opentextbc.ca/studentsuccess/chapter/learning-preferences-and-strengths/ Examine Applicable Strategies

Accessed at:

https://opentextbc.ca/studentsuccess/chapter/examine-applicable-strategies/ Planning the Presentation

Accessed at:

https://opentextbc.ca/studentsuccess/chapter/planning-the-presentation/

1. Oh, U. L. (May 26, 2020). Talking to kids about xenophobia. National Geographic. Retrieved from: https://www.nationalgeographic.com/family/2020/05/talking-to-kids- about-xenophobia-coronavirus/

2. https://writingcenter.unc.edu/tips-and-tools/book-reviews/

Community Engagement Toolkit for Planning (2017) Guiding principles [pp 7-24] Developing Community Engagement Plan [pp 13-

29]. https://examples.yourdictionary.com/examples-of-good-and-bad-researchquestions.html https://www.ayoa.com/ourblog/what-is-mind-mapping-and-how-can-you-use-it/

Hall, Hellen (2012) Reverse Outlines Reverse Outlines: Take A part Your Paper to Put it BackTogether Right. Accessed at:

https://www.semanticscholar.org/paper/Reverse- Outline-s-Reverse-Outlines-%3A-Take-Apart-to-Hall/c0373e42616395ea9edf5d5bd5cbe6eb1bb923e2

4. G. B. Thomas, R. L. Finney, "Calculus and Analytic Geometry", National Book Foundation, 9th ed. (1995)
5. G. Strang, "Calculus", Wellesley-Cambridge, 2nd ed., (2010).
6. E. W. Swokowski, M. Olinick, D. Pence, and J. A. Cole, "Calculus"; Pws Pub Co; 6th ed. (1994).

## PHY-126 BASIC ECONOMICS

### Credit Hours: 03

**Introduction** Introduction to Economics, Definition of Economics, importance of economics Scope of Economics.

Micro & Macro Economics Positive & Normative Economics, Economic Problem

**Consumer Behavior** Utility, Meaning and Definition of Utility, Characteristics of utility, Law of Diminishing Marginal Utility, Indifference Curve Analysis, Budget line. Consumer Equilibrium through Indifference Curve approach

**Demand** Demand, definition of demand, types of demand; individual and Market demand, Law of Demand, Shift and Movements in Demand Curve, Price Elasticity of Demand its types, Measurement of elasticity of demand i.e. Point Elasticity and Arc Elasticity of Demand

**Supply** Supply: Supply vs Stock, Law of Supply, Change in Supply, Movement and Shift in supply

**Market** Market, types of market; perfect competition, Monopoly, oligopoly monopolistic competition

**Economic System** Economic System: Capitalism, Socialism. Mixed Economic System, Islamic Economic System, Importance of Islamic Economic System

**Concepts of National Income** National Income, Gross Domestic Product, Gross National Product, Net National Product, Per capital income

**Money** Definition of money, kinds of money, Functions of money and Evolution of money.

**Bank** Bank, types of Bank. Commercial Banks and its functions, Central Bank and functions.

**Public Finance** Government revenue, Sources of government revenue govt expenditure and Head of government expenditure ,Fiscal policy, instruments of fiscal policy,

**Budget**: types of budget i.e Balance budget, budget deficit and surplus budget

**International Trade** Trade, Background of Trade, Difference between domestic and international trade Importance of International Trade,

## PHY- 127 Pre- Calculus II and analytical geometry (Cr Hr 00)

**Differential equation**: Introduction, ODE, formation of differential equation, solution of differential equation.

**Analytical geometry**: Cartesian plane, distance formula, line segment, division of line segment, slope of straight line, standard form of equation of straight line, distance of a point from a line, angle between lines, area of triangular region.

**Conics-1**: Introduction, circle, equation of circle, properties of circle, tangent and normal, parabola and its elements, general and standard form of parabola, ellipse and its elements, standard form of equation of ellipse, hyperbola and its elements, standard form of equation hyperbola.

**Recommanded books:**

1-Calculus and analytical geometry 9th edition (G.B Thomas, R.L Finney)

2- G.Strang, calculus Wellesley Cambridge 2nd edition (2010)

**PHY-231 WAVES & OSCILLATIONS**

**Pre-requisites:** Mechanics, Calculus II

**Credit Hours:** Three (3)

**Objective(s):** To develop a unified mathematical theory of oscillations and waves in physical systems

**Simple and Damped Harmonic Oscillation:** Mass-Spring System; Simple Harmonic Oscillator Equation; Complex

Number Notation; LC Circuit; Simple Pendulum; Quality Factor; LCR Circuit

**Forced Damped Harmonic Oscillation:** Steady-State Behavior; Driven LCR Circuit; Transient Oscillator Response; Resonance

**Coupled Oscillations:** Two Spring-Coupled Masses; Two Coupled LC Circuits; Three Spring Coupled Masses; Normal

Modes; Atomic and Lattice Vibrations

**Transverse Waves:** Transverse Standing Waves; Normal Modes; General Time Evolution of a Uniform String; Phase

Velocity; Group Velocity

**Longitudinal Waves:** Spring Coupled Masses; Sound Waves in an Elastic Solid; Sound Waves in an Ideal Gas
**Travelling Waves:** Standing Waves in a Finite Continuous Medium; Traveling Waves in an Infinite Continuous Medium; Energy Conservation; Transmission Lines; Reflection and Transmission at Boundaries

**Wave Pulses:** Fourier Series and Fourier Transforms; Wave-Packets and Bandwidth

**Multi-Dimensional Waves:** Plane Waves; Three-Dimensional Wave Equation; Electromagnetic waves; Laws of

Geometric Optics; Waveguides; Cylindrical Waves

**Interference and Diffraction of Waves:** Double-Slit Interference; Single-Slit and Double-slit Diffraction

**Recommended Books:**

1. J. Pain, "The Physics of Vibrations and Waves", John Wiley, 6th ed., (2005).
2. A. P. French, "Vibrations and Waves", CBS Publishers, 2003.
3. F. S. Crawford, Jr., "Waves and Oscillations", Berkeley Physics Course, Vol. 3, McGraw-Hill, (1968).
4. A. Hirose, and K .E. Lonngren, "Introduction to Wave Phenomena", Krieger Publications, (2003).

**PHY- 232 MODERN PHYSICS**

**Pre-requisites** Mechanics, Electricity and Magnetism

**Credit Hours:** Three (3)

**Objective(s):** To understand the non-classical aspects of Physics, applications of Quantum Physics in micro-scale, atomic and molecular structure and processes

**Motivation for Non--Classical Physics:** Quantum interference, blackbody radiation and ultraviolet catastrophe, Planck's quantization. Wace-Particle Duality: Photoelectric effect, Compton effect, production and properties of X-rays, diffraction of X-rays, concept of matter waves, de Broglie relationship, electrons are waves, electron diffraction, particulate nature of matter, contributions of Faraday (atoms exist), Thomson (electron exists), Rutherford (nucleus exists) and Bohr (quantization of energies inside an atom), wave packets and wave groups, dispersion, Heisenberg uncertainty principle, direct confirmation of quantization through Franck-Hertz experiment and spectroscopy, working of electron microscopes.

**Quantum Mechanics in One Dimension:** The concept of a wavefunction, time independent Schrodinger equation and interpretation of the equation, solving the Schrodinger equation for a free particle, for a particle inside an infinite box, relationship between confinement and quantization, working of a CCD camera.

**Quantum Mechanical Tunneling:** Concept of tunneling, reflection and transmission of wave functions from barriers, applications: radioactivity, scanning tunneling microscope, decay of black holes.

**Quantum Mechanics in Three Dimensions**: The Hydrogen atom, orbitals, angular momentum and its quantization, orbital magnetism, Zeeman effect, concept of spin, Pauli's exclusion principle, Building of the periodic table, magnetic resonance and MRI, why is iron magnetic? White dwarfs, and neutron stars.

**From Atoms to Molecules and Solids**: Ionic bonds, covalent bonds, hydrogen bonds, molecular orbitals, how crystals are different from amorphous solids? Why and how do metals conduct electricity? Bands in solids, semiconductors, introduction to LED's and lasers, introducing grapheme. Nuclear Structure: Size and structure of nucleus, nuclear forces, radioactivity and nuclear reactions, radiocarbon dating.

**Recommended Books:**

1. R.A. Serway, C.J. Moses and C.A. Moyer, "Modern Physics", Brooks Cole, 3rd ed. 2004.

2. Paul A. Tipler and Ralph A. Llewellyn, "Modern Physics", W H Freeman and Company 6th ed. 2012.

3. Arthur Beiser, "Concepts of Modern Physics", McGraw-Hill, 6th ed. 2002.

4. R. M. Eisberg and R. Resnick, "Quantum Physics of Atoms, molecules, Solids, Nuclei and Particles", John Wiley, 2nd ed. 2002.

**PHY-233 Lab-III (waves & Oscillations)**

**Credit Hours:** One (1)

**Heat:** Calorimetry, heat transfer, Newton's cooling under ambient and forced convection and radiation, measurement of temperature using Si diodes, thermistors, thermocouples and RTD's, black bodies, heat pumps and heat engines, investigation of gas laws and laws of thermodynamics, thermal conductivity by pulsed heating of a metal rod, measurement of latent heats and specific heat capacities, temperature control using proportional-integral-derivative (PID) schemes, thermal expansion and its measurement using strain gauges.

**Waves and Oscillations, Sound:** Resonance in a stretched string, normal modes of oscillation, dispersion relations for mono- and di-atomic lattices, coupled oscillators, nonlinear oscillations exemplified by resistance-inductance-diode circuits, magnetic pendulums, accelerometers, measurement of the speed of sound under conditions of varying temperature, solitons, Lorentz pendulum, waves in water, beats, superposition of harmonic motion (Lissajous patterns), sonometer.

**Recommended Books:**

1. A. C. Melissinos and J. Napolitano, “Experiments in Modern Physics”, Academic Press, 2nd ed. (2003).
2. J. H. Moore, C. C. Davis, M. A. Coplan, and S. C. Greer, "Building Scientific Apparatus", Cambridge University Press, 4th ed. (2009).
3. J. R. Taylor, "An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements", University of Science Books, 2nd ed. (1996).
4. L. Kirkup and R. B. Frenkel, “An Introduction to Uncertainty in Measurement”, Cambridge University Press, (2006).
5. G. L. Squires, "Practical Physics", Cambridge University Press, 4th ed. (2001).
6. Y. Tsividis, "A First Lab in Circuits and Electronics", John Wiley (2001).

**PHY-234 Islamic Studies** **Credit Hours: 2 (2-0)**

**Domain: GE**

**Note**: May be taught in Urdu.

Course Contents (English & Urdu)

| English | Urdu |
|---|---|
| 1. Introduction to Quranic Studies<br>• Basic Concepts of Quran<br>• History of Quran<br>• Uloom-ul -Quran | **1. قرآنی علوم کا تعارف**<br>• قرآن مجید کے بنیادی اصطلاحات<br>• تاریخ تدوین وجمع قرآن<br>• علوم القرآن |
| 2. Study of Selected Text of Holy Quran<br>• Verses of Surah al-Furqan Related to Social Ethics (Verse No.6377) | **2. منتخب آیات کریمہ کا مطالعہ**<br>• معاشرتی آداب سے متعلق سورہ الفرقان کی آیات نمبر 63-77 |

| | |
|---|---|
| • Verses of Surah Al-Hashr (18,19, 20) Related to thinking, Day of Judgment<br>• | • آخرت اور اسکی فکر سے متعلق سورہ الحشر کی آیات 18-20<br>• |
| • Verses of Surah Al-Saff Related to Tafakur, Tadabbur (Verse No-1,14) | • کائنات میں غور و فکر سے متعلق سورہ الصف کی آیات 1-14 |
| 3. Seerat of Holy Prophet (PBUH)<br>• Life of Holy Prophet (PBUH) in Makkah (After Prophethood) and its Important Events<br>• Life of Holy Prophet (PBUH) in Madinah and its Important Events | **3. سیرت طیبہ ﷺ کا مطالعہ**<br>• مکہ مکرمہ میں بعد از نبوت حضور ﷺکی زندگی اور اہم واقعات<br>• مدینہ منورہ میں حضور ﷺکی زندگی اور اہم واقعات |
| 4. Introduction to Sunnah<br>• Basic Concepts of Hadith<br>• History of Hadith<br>• Kinds of Hadith<br>• Legal Position of Sunnah | **4. تعارف حدیث و سنت**<br>• سنت و حدیث کا تعارف و اہمیت<br>• تاریخ حدیث<br>• حدیث کی اقسام<br>• سنت کا شرعی مقام |
| **5. Selected Study from Text of Hadith**<br>• عن انس بن مالک رضی اللہ عنہ قال قال رسول اللہ ﷺ:"من خرج فی طلب العلم فھو فی سبیل اللہ حتّیٰ یرجع"۔<br>• عن ابی امامۃ رضی اللہ عنہ قال قیل یارسول اللہ!الررجلان یلتقیان ایھما یبدا بالسلام فقال اولاھما باللہ"<br>• عن ابی سعید الخدری رضی اللہ عنہ قال سمعت رسول اللہ ﷺ یقول:" من رأیٰ منکم منکراً فلیغیرہ بیدہ فان لم یستطع فبلسانہ فان لم یستطع فبقلبہ و ذٰالک اضعف الایمان"<br>• عن ابی ھریرۃ رضی اللہ عنہ قال قال رسول اللہ ﷺ:" آیۃ المنافق ثلاث اذا حدث کذب واذا وعد اخلف واذا ائتمن خان"<br>• عن ابی ھریرۃ رضی اللہ عنہ قال قال رسول اللہ ﷺ:" ایاکم و الحسد فان الحسد یأکل الحسنات کما تأکل النار الحطب"۔<br>• عن ابی ھریرۃ رضی اللہ عنہ ان رسول اللہ ﷺ قال:" من کان یؤمن باللہ والیوم الآخر فلیقل خیرا او لیصمت ومن کان یؤمن باللہ والیوم الآخر فلیکرم جارہ ومن کا ن یؤمن باللہ والیوم الآخر فلیکرم ضیفہ"۔<br>• عن عبداللہ ابن عمربن الخطاب رضی اللہ عنھما قال سمعت رسول اللہ ﷺیقول:بنی الاسلام علیٰ خمس شھادۃ ان لا الٰہ الا اللہ وان محمدا عبدہٗ ورسولہ واقام الصلوٰۃ وایتاء الزکوٰۃ وحج البیت وصوم رمضان<br>• عن ابی ھریرۃ رضی اللہ عنہ ان رسول اللہ ﷺ قال:" من حسن اسلام المرء ترکہ مالایعنیہ"۔ | |
| **6. Introduction to Islamic law and jurisprudence**<br>• History and Importance of Islamic Law and Jurisprudence<br>• Sources of Islamic law and jurisprudence<br>• Nature of differences in Islamic law<br>• Islam and sectarianism | **6. اسلامی قانون اور فقہ کا تعارف**<br>• اسلامی قانون اور فقہ کی تاریخ اور اہمیت<br>• اسلامی قانون اور فقہ کے ذرائع<br>• اسلامی قانون میں اختلافات کی نوعیت<br>• اسلام اور فرقہ واریت |

| | |
|---|---|
| 7. Political System of Islam<br>• Basic Concepts of Islamic Political System<br>• Islamic Concept of Sovereignty<br>• Basic Institutions of government in Islam | **7. اسلام کا سیاسی نظام**<br>• اسلامی سیاسی نظام کے بنیادی تصورات<br>• اسلامی تصور حاکمیت<br>• اسلام میں حکومت کے بنیادی ادارے |
| 8. Social System of Islam<br>• Basic concepts of social system of Islam<br>• Elements of Family<br>• Ethical Values of Islam | **8. اسلام کا معاشرتی نظام**<br>• اسلام کے معاشرتی نظام کے بنیادی تصورات<br>• خاندان کے عناصر<br>• اسلام کی اخلاقی اقدار |

## Recommended Readings


- Ahmad Hasan, "Principles of Islamic Jurisprudence" Islamic Research Institute, International Islamic University, Islamabad (1993)
- Dr. Muhammad Zia-ul-Haq, "Introduction to Al Sharia Al Islamia" Allama Iqbal Open University, Islamabad (2001)
- H.S. Bhatia, "Studies in Islamic Law, Religion and Society" Deep & Deep Publications New Delhi (1989)
- Hameed ullah Muhammad, 'Introduction to Islam Maulana Muhammad Yousaf Islahi,"
- Hameed ullah Muhammad, "Emergence of Islam" , IRI, Islamabad
- Hameed ullah Muhammad, "Muslim Conduct of State"
- Hussain Hamid Hassan, "An Introduction to the Study of Islamic Law" Leaf Publication Islamabad, Pakistan.

Mir Waliullah, "Muslim Jurisprudence and the Quranic Law of Crimes" Islamic Book Service (1982)


**PHY- 128Ethics Credit Hours: 2+0**

**Content:**

Elementary theories in normative ethics of behavior, core areas of ethics, cultural relativism, religious approaches to ethics

Intermediate theories in normative ethics of behavior, utilitarianism, Kant theory, social contract theory

**Recommended Books:**


***Barsky,A. E.(2010): Ethics and values in social works: An Interogative Approach to Comprehansive Curricullum, Oxford University Press, New York***

***Cahn, S.M.(1998) Ethics ; Hostory, Theory and Contemporary Issues. Oxford University Press, New York***

**PHY-235 CHEMISTRY-I**

**Credit Hours:** Three (3) **Introduction of Chemistry**

The study of chemistry, matter, Mass and Weight, Atoms and Molecules, ions, Relative atomic mass and relative molecular mass, Empirical and molecular formula, Mole, Stoichiometric calculations, Limiting reactants and percentage yield of reactions.

**Atomic Structure**

Fundamental particles, Discovery of electron, Discovery of proton, Discovery of neutron, Model of atom, X-rays and atomic number, Dual nature of electron, Heisenberg's uncertainty principle, Quantum numbers, Shapes of orbital's, Electronic configuration.

**States of Matter**

**Gases:** Ideal gas laws, kinetic theory of gases, Collusion properties, real gases, Vander waals equation, The principle of corresponding state.

**Liquid:** Vapour pressure, measurements of vapour pressure, factors effecting the vapour pressure, Surface tension, measurements of Surface tension, factors effecting the surface tension, applications of surface tension, Viscosity, measurements of, Refractive index, Dipole moment.

**Solids**: Types of solid, Properties of crystalline solids, Crystal Lattice, Crystals and their classification, Investigation of structure (X-ray Diffraction, Bragg's law), Classification of solids.

**Basic Concepts of Organic chemistry**

Delocalized chemical bonding, Resonance, Hyper conjugation, Hydrogen bonding, Tautomerism, Inductive effect, Aromaticity

**PHY-236 LINEAR ALGEBRA**

**Credit Hours:** Three (3)

Review of vectors in 3 dimensions [(arrows) with a view of abstraction into properties of vector spaces in N dimensions (closure, associativity and commutativity of addition, existence of identity and inverse, distributivity of scalar multiplication), idea of vector norm in 3 dimensions, orthogonality, expansion in a basis, multiplication of vectors in 3 dimensions, applications of vector algebra to geometry and physics], vector spaces in N dimensions (definition, basis, inner product), linear operators, matrices (matrix algebra, functions of matrices, transpose, complex and Hermitian conjugates, trace, determinant, inverse, rank, special types of matrices – diagonal, triangular, symmetric and antisymmetric, orthogonal, Hermitian and anti-Hermitian, unitary, normal, eigenvalue problem, similarity transformations and change of basis, diagonalisation, simultaneous linear equations), , Fourier series as an application of the ideas of linear algebra to the space of periodic functions (identification of the space of periodic functions of a certain period as a linear vector space, identification of sinusoidal functions as basis vectors in this infinite dimensional vector space, properties of Fourier series, sets of functions, eigenvalue problem in the context of differential operators, adjoint and Hermitian operators, properties of Hermitian operators (reality of eigenvalues, orthogonality of eigenfunctions, completeness of eigenfunctions eigen basis),

**Recommended Books:**

1. K. F. Riley, M. P. Hobson and S. J. Bence, "Mathematical Methods for Physicists", Cambridge University Press (2006).
2. P. V. O'Neil, "Advanced Engineering Mathematics", 7th ed. CL Engineering, (2011).

**PHY-241 OPTICS**

**Pre-Requisites:** Waves and Oscillations

**Credit Hours:** Three (3)

**Objective(s):** To understand optical phenomena and their uses in physical systems

**Propagation of Light & Image Formation:** Huygens' Principle; Fermat's Principle; Laws of Reflection and Refraction;

Refraction at a Spherical Surface, Thin Lenses; Newtonian Equation for a Thin Lens

**Matrix Methods in Paraxial Optics:** Ray Transfer Matrices; Thick Lens; Significance of System Matrix Elements; Cardinal Points of an Optical System with examples; Optical Instruments including Simple Magnifiers; Telescopes and Microscopes; Chromatic and Monochromatic Aberrations; Spherical Aberrations; Coma; Distortion; Stops; Pupils; Windows

**Superposition & Interference:** Standing Waves; Beats; Phase and Group Velocities; Two-Beam and Multiple-Beam Interference; Thin Dielectric Films; Michelson and Fabry-Pérot Interferometers; Resolving Power; Free-Spectral Range
**Polarization:** Jones Matrices; Production of Polarized Light; Dichroism; Brewster's Law; Birefringence; Double Refraction

**Fraunhofer Diffraction:** From a Single Slit; Rectangular and Circular Apertures; Double Slit; Many Slits; Diffraction

Grating; Dispersion; Resolving Power Blazed Gratings

**Fresnel Diffraction:** Zone Plates; Rectangular Apertures; Cornu's Spiral

**Coherence & Holography:** Temporal Coherence; Spatial Coherence; Holography of a Point object and an Extended Object

**Laser Basics:** Stimulated Emission; Population Inversion; Resonators; Threshold and Gain; Multilayered Dielectric Films.

**Recommended Books:**

1. F. Pedrotti, L. S. Pedrotti and L. M. Pedrotti, "Introduction to Optics", Pearson Prentice Hall, 3rd ed. (2007).
2. E. Hecht and A. Ganesan, "Optics", Dorling Kindersley, 4th ed. (2008).
3. M. V. Klein and T. E. Furtak, "Optics", John Wiley, 2nd ed. (1986).

4. K. K. Sharam, "Optics: Principles and Applications", Academic Press, (2006).
5. C. A. Bennett, "Principles of Physical Optics", John Wiley, (2008).

**PHY-242 Lab-IV(optics)**

**Credit Hours:** One (1)

**Optics (basic and advanced) and Spectroscopy:** Sources of light including bulbs, light emitting diodes, laser diodes and gas lasers, experiments demonstrating optical phenomena such as interference, diffraction, linear motion, reflection, refraction, dispersion, Michelson interferometry, measurement of refractive index using interferometry, measurement of the speed of light, diffraction gratings and multiple-slit interference, thin film interference and Newton's rings, use of digital cameras for optics experiments, mode structure of lasers, use of spectrometers and monochromators, wavelength tuning of laser diodes, rainbows, emission spectroscopy of low-pressure gases (hydrogen), alkali spectra and fine structure, hyperfine structure of rubidium, vibrational spectrum of nitrogen, Lambert-Beer's law, optical polarization, magneto-optical Faraday rotation.

**Recommended Books:**

1. A. C. Melissinos and J. Napolitano, "Experiments in Modern Physics", Academic Press, 2nd ed. (2003).
2. J. H. Moore, C. C. Davis, M. A. Coplan, and S. C. Greer, "Building Scientific Apparatus", Cambridge University Press, 4th ed. (2009).
3. J. R. Taylor, "An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements", University of Science Books, 2nd ed. (1996).
4. L. Kirkup and R. B. Frenkel, "An Introduction to Uncertainty in Measurement", Cambridge University Press, (2006).
5. G. L. Squires, "Practical Physics", Cambridge University Press, 4th ed. (2001).
6. Y. Tsividis, "A First Lab in Circuits and Electronics", John Wiley (2001

**PHY-243 Ideology and constitution of Pakistan**

**Credit Hours:**Two (2)

*Course Introduction*

*Pakistan studies is an important course at this university in which students' study about their motherland. The following are the specific objectives of the course.*

- *To develop vision of Historical Perspective, Government, Politics, Contemporary Pakistan, ideological background of Pakistan.*
- *To study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.*

**Course Outline**

**Introduction to Ideology**

Defining the Term Ideology, Role of Ideas, Contours of Ideology, Ideology, Truth and Power

Types of Ideologies, Left, Right and Center Debate, Old and New Ideologies, Views about Ideologies

**Ideology of Pakistan**

Aims and Objects of Pakistan's Formation

Ideology of Pakistan – its Importance

Basics of Pakistan's Ideology

Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Iqbal's and M. A. Jinnah's Notions on Ideology of Pakistan

**Constitution, Government and Politics**

Definitions, Features, and Functions

Constitutional Development in Pakistan 1947-1973: Constitution of 1956, 1962

Salient Features of Constitution of Pakistan 1973

Fundamental Rights in Constitution of Pakistan 1973

Martial Law 1977-88,

Civilian Rule 1988-99

Martial Law 1999 Onward

**Pakistan – Land and Peoples**

Geography and its Importance

Natural resources and Their use

Agriculture and Industry

Population, Manpower, and Education

**Contemporary Pakistan**

Economic Institutions and Issues

Society and Social Structure

Foreign Policy of Pakistan and Challenges

**Recommended Books:**

1. Burki, Shahid Javed. State and Society in Pakistan, The Macmillan Press Ltd 1980.
2. Akbar, S. Zaidi. Issue in Pakistan's Economy. Karachi: Oxford University Press, 2000.
3. S.M. Burke and Lawrence Ziring. Pakistan‟s Foreign policy: An Historical analysis. Karachi: Oxford University Press, 1993.
4. Mehmood, Safdar. Pakistan Political Roots and Development. Lahore, 1994.
5. Wilcox, Wayne.The Emergence of Bangladesh., Washington: American Enterprise, Institute of Public Policy Research, 1972.
6. Mehmood, Safdar. Pakistan Kayyun Toota, Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd.
7. Amin, Tahir. Ethno -National Movement in Pakistan, Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, Lawrence. Enigma of Political Development. Kent England: WmDawson and sons Ltd, 1980.
9. Zahid, Ansar. History and Culture of Sindh. Karachi: Royal Book Company, 1980.
10. Afzal, M. Rafique. Political Parties in Pakistan, Vol. I, II and III. Islamabad: National Institute of Historical and cultural Research, 1998.

11. Sayeed, Khalid Bin. The Political System of Pakistan. Boston: Houghton Mifflin, 1967.
12. Aziz, K.K. Party, Politics in Pakistan, Islamabad: National Commission on Historical and Cultural Research, 1976.
13. Muhammad Waseem, Pakistan Under Martial Law, Lahore: Vanguard, 1987.
14. Haq, Noor ul. Making of Pakistan: The Military Perspective. Islamabad: National Commission on Historical and Cultural Research, 1993.

**PHY-244 PROBABILITY AND STATISTICS**

**Credit Hours:** Three (3)

**Course Outline:**

**Course contents**: Introduction to statistics and data analysis (mean, standard deviation and variance), samples, populations and role of probability. Sampling procedures. Discrete and continuous data. Probability: sample space, events, counting samples points, probability of an event, additive rules, conditional probability, independence, and the product rule, Bayes' rule. Random variables and probability distributions. Mathematical expectation: mean of random variable, variance and covariance of random variables. Mean and variance of linear combinations of random variables. Discrete probability distribution (binomial and Poisson). Continuous probability distributions (normal and uniform).

**Recommended Books:**

• Susan Milton and Jesse C Arnold, "Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences," Fourth Edition, 2003, McGraw-Hill, ISBN: 007246836.

• William Mendenhall and Terry Sincich, "Statistics for Engineers and the Sciences," Fifth Edition, 2007, Prentice Hall, ISBN10: 0131877062

## PHY-245 Entrepreneurship

## Credit Hours: 2+0

**Defining Entrepreneurship:** Creation economic organization, dimensions of entrepreneurship.

**The Macro Environment for Entrepreneurship:** process of environmental analysis, sources of opportunities, industry and market structure.

**The Competitive Environment:** the perfect competition model, industry analysis, buyer power, supplier power, the threats of substitutes, entry barriers, rivalry between firms, competitor's analysis.

**The International Environment:** the macro environment of international entrepreneurship, international entrepreneurial strategies, international organization behavior.

**Business Plan and Entrepreneurial Strategy:** entry wedges, resource based strategies, strategy and industrial environment.

**Marketing New Ventures:** the marketing of entrepreneurship interface, marketing concepts and orientation, marketing strategy and sales forecasting.

**Element of New Ventures:** creating the organization

**SME Definition:** Importance of SME, SME in Pakistan.

**Best Quality Management Practice in SME:** customer relation management in SME.

**Strategies of success of SME:** The Business plan. Case study, Practical plan and Implementation

**RECOMMENDED BOOKS**

1. SMALL BUSINESS MANAGEMENT A CASE STUDY APPROACH, Devid Stokes, Latest Edition**.**
2. Mare J.Dollinger Entrepreneurship: Strategies and Resources. Austen Press**.**

**PHY-246 DIFFERENTIAL EQUATIONS**

**Credit Hours:** Three (3)

Introduction to ODEs (physical motivation), First order ODEs (separable variables, homogeneous equations, exact equations, linear equations, Bernoulli equation and other examples), applications of first order ODEs – linear and non- linear, linear differential equations of higher order (initial value and boundary value problems, linear dependence and independence, solutions of linear equations, constructing a second solution from a known solution, homogeneous linear equations with constant coefficients, undetermined coefficients, variation of parameters), (differential equations with variable coefficients (Cauchy-Euler equation, power series solution of differential equations – solutions about ordinary and singular points-Legendre's and Bessel's equations as examples), Laplace transform (Laplace transform and its inverse and properties, use in solving differential equations, Dirac delta function).

**Recommended Books:**

1. D. G. Zill and M. R. Cullen, "Differential Equations with Boundary Value Problems", 3rd ed. National Book Foundation. (2008)

2. E. Kreyszig, "Advanced Engineering Mathematics", John Wiley, 8th ed. (1999).

3. K. F. Riley, M. P. Hobson and S. J. Bence, "Mathematical Methods for Physicists", Cambridge University Press (2006).

**PHY-247 Fables, Wisdom Literature, and Epic**

**Credit Hours: (2+0)**

This course has three components containing both readings and related activities: The first component is about fables—that is, stories with animal characters having human attributes. The second component concerns wisdom literature and looks specifically at some of the stories, both in prose and poetry, of the famous Persian literary figure Sa'di. We shall introduce this author to you. The third component is on the world's renowned epic—the Odyssey of another literary giant, Homer**.**

## I. FABLES

کلیلہ ودمنہ یا خرد افروز از سراج الدین (لاہور: مجلس ترقی ادب، 1963) کے دو ابواب شامل نصاب ہیں۔

باب پنجم –دوستوں کی یک دلی کے فائدے میں

باب ششم –دشمنوں کے کاروبار و دنیا کے سوچنے اور ان کے فریب سے نڈر رہنے میں

**بانگِ درا**

سر محمد اقبال، کلیاتِ اقبال (لاہور: اقبال اکیڈمی، 2021)

1. ایک مکڑا اور مکھی
2. ایک پہاڑ اور گلہری
3. ایک گائے اور بکری
4. پرندے کی فریاد
5. دریا موج
6. جگنو
7. ایک پرندہ اور جگنو
8. ہمدردی

## II. WISDOM LITERATURE

**GULISTĀN-E SA'DĪ** (گلستانِ سعدی)

شیخ شرف الدین مصلح سعدی شیرازی، گلستان مترجم، مترجمہ مولانا قاضی سجاد حسین (لاہور: مکتبہ رحمانیہ، س ن)

دس منتخب حکایات

1- باب دوم، حکایت ششم: زاہدے مہمان پادشاہے بود، صفحہ: 86

2- باب اول، حکایت بیست: آوردہ اند کہ نوشیروانِ عادل را رشکار، صفحہ 57

3- باب اول، حکایت بیست و یک: عاملے را شنیدم کہ خانہ رعیت خراب کردے، صفحہ 57

4- باب اول، حکایت بیست و ہفتم: خالے را حکایت کنند کہ ہیزم درویشاں، صفحہ 66

5- باب اول، حکایت بیست و نہم: درویشے مجرد بگوشہ صحرائے نشستہ بود، صفحہ 69

6- باب اول، حکایت سی و یک: پادشاہے بکشتن اسیرے اشارد کرد گفت، صفحہ 71

7- باب اول، حکایت سی و ششم: دو برادر بودند یکے خدمت سلطان کردے، صفحہ 75

8- باب اول، حکایت سی و ہفتم: کسے مژدہ پیش نوشیرواں عادل بردو گفت، صفحہ 76

9- باب اول، حکایت چہل و یک: اسکندر رومی را پرسیدند، صفحہ 80

10- باب دوم، حکایت سی و ہفتم: فقیہے پدر را گفت ہیچ از یں سخنانِ دلاویز، صفحہ 115

## III. EPIC

### Odyssey (جہاں گرد کی واپسی)

ہومر، جہاں گرد کی واپسی، مترجمہ محمد سلیم الرحمٰن (لاہور: القا پبلی کیشنز، 2012)

باب دوازدہم: پر آشوب مرحلے، ص 160 تا 172

**PHY-351 MATHEMATICAL METHODS OF PHYSICS-I**

**Pre-requisite:** Differential Equations

**Credit Hours:** Three (3)

**Objectives:** To give an understanding of the Partial Differential equations and their uses in Physics; Introduction to Special Functions; Complex Functions and their Applications

**Partial Differential Equations (PDEs):** Introduction to Important PDEs in Physics (Wave Equation; Diffusion Equation; Poisson's Equation; Schrodinger's Equation); General form of Solution; General and Particular Solutions (First Order; Inhomogeneous; Second Order); Separation of Variables in Cartesian Coordinates; Superposition of Separated Solutions; Separation of Variables in Curvilinear Coordinates; Special Functions; Integral Transform Methods; Green's Functions.

**Complex Analysis:** Review (Polar form of Complex Numbers and De Moivre's Theorem; Complex Logarithms and Powers); Functions of a Complex Variable; Cauchy-Riemann Conditions; Power Series in a Complex Variable and Analytic Continuation with Examples; Multi-valued Functions and Branch Cuts; Singularities and Zeroes of Complex Functions; Complex Integration; Cauchy's Theorem; Cauchy's Integral Formula; Laurent Series and Residues; Residue Integration Theorem; Definite Integrals using Contour Integration.

**Special Functions:** Bessel Functions; Legendre Functions; Associated Legendre Functions; Spherical Harmonics; Hermite Polynomials Beta Function; Gamma Function.

**Recommended Books:**

1. G. Arfken, H. J. Weber, and F. E. Harris, "Mathematical Methods for Physicists", Academic Press, 7th ed. (2012).

2. K. F. Riley, M. P. Hobson, S. J. Bence, "Mathematical Methods for Physicists", Cambridge University Press, (2006).

3. E. Kreyszig, "Advanced Engineering Mathematics", John Wiley, 8th ed. (1999).

**PHY-352 ELECTROMAGNETIC THEORY-I**

**Pre-requisites:**Electricity and Magnetism,Calculus-

**Credit Hours:** Three (3)

**Objectives:**To give an understanding of the basic electromagnetic theory

**Review of Calculus:** vector algebra and calculus, Cartesian coordinates spherical coordinates. (1 week). The Dirac Delta Function: Review of vector calculus using example of Dirac Delta function, the divergence of r/r2, the one-dimensional and the three- dimensional Dirac delta functions. The theory of vector fields: the Helmoholtz theorem, potentials.

**Electrostatics:** The electric field: introduction, Coulomb's law, the electric field, continuous charge distributions.

**Divergence and curl of electrostatic fields:** field lines, flux and Gauss's law, the divergence of E, applications of Gauss's law, the curl of E.

**Electric potential:** introduction to potential, comments on potential, Poisson's equation and Laplace's equation, the potential of a localized charge distribution, summary, electrostatics boundary conditions, Work and energy in electrostatics: the work done to move a charge, the energy of a point charge distribution, the energy of a continuous charge distribution, comments on electrostatic energy. Conductors: basic properties, induced charges, surface charge and the force on a conductor, capacitors.

**Special Techniques**: Laplace's equation: introduction, Laplace's equation in one, two and three dimensions, boundary conditions and uniqueness theorems, conductors and second uniqueness theorems.

**The Method of Images:** The classic image problem, induced surface charge, force and energy, other image problems. Multi-pole Expansion: Approximate potential at large, the monopole and dipole terms, origin of coordinates in multi-pole, expansions, the electric field of a dipole. Electric Fields in Matter: Polarization: dielectrics, induced dipoles, alignment of polar molecules, polarization. The field of a polarized object: bound charges, physical interpretation of bound charges, and the field inside a dielectric.

**The electric displacemen**t: Gauss's law in the presence of dielectrics, a deceptive parallel, boundary conditions. Linear Dielectrics: susceptibility, permittivity, dielectric constant, boundary value problems with linear dielectrics, energy in dielectric systems, forces on dielectrics.

**Magnetostatics:** The Lorentz Force law: magnetic fields, magnetic forces, currents.

**The Biot-Savart Law**: steady currents, the magnetic field of a steady current. The divergence and curl of B: straight-line currents, the divergence and curl of B, applications of Ampere's law, comparison of magnetostatics and electrostatics.

**Magnetic Vector Potential**: the vector potential, summary, magnetic boundary conditions, multi-pole expansion of the vector potential. Magnetic Fields in Matter: Magnetization, diamagnets, paramagnets, ferromagnets, torques and forces on magnetic dipoles, effect of a magnetic field on atomic orbits, magnetization.

**The Field of a Magnetized Object:** bound currents, physical interpretation of bound currents, and the magnetic field inside matter. The auxiliary field H: Ampere's law in magnetized materials, a deceptive parallel, boundary conditions. Linear and nonlinear media: magnetic susceptibility and permeability, ferromagnetism.

**Recommended Books:**

**1**. D. J. Griffiths, "Introduction to Electrodynamics", Prentice Hall, 3rd ed. 1999.

2. M. N. O. Sadiku, "Elements of Electromagnetics", Oxford University Press, 5th ed. 2009.

3. F. Melia, "Electrodynamics", University of Chicago Press, 2001.

4. Hearld J and W. Muller-Kristen, "Electrodynamics", World Scientific Publishing, 2nd ed. 2011.

**PHY-353 CLASSICAL MECHANICS**

**Credit Hours:** Three (3)

**Objectives:** To give a basic understanding of the classical mechanics concepts

**Review of Newtonian Mechanics:** Frame of reference, orthogonal transformations, angular velocity and angular acceleration, Newton's laws of motion, Galilean transformation, conservation laws, systems of particles, motion under a constant force, motions under variable force, time-varying mass system.

**The Lagrange Formulation of Mechanics and Hamilton Dynamic**s: Generalized co-ordinates and constraints, D'Alembert's principle and Lagrange's Equations, Hamilton's principle, integrals of motion, non conservative system and generalized potential, Lagrange's multiplier method, the Hamiltonian of a dynamical system, canonical equations, canonical transformations, Poisson brackets, phase space and Liouville's theorem.

**Central Force Motion:** The two-body problem, effective potential and classification of orbits, Kepler's laws, stability of circular orbits, hyperbolic orbits and Rutherford scattering, center of mass co-ordinate system, scattering cross-sections.

**Motion in Non-inertial Systems:** Accelerated translational co-ordinate system, dynamics in rotating co-ordinate system, motion of a particle near the surface of the earth.

**The Motion of Rigid Bodies:** The Euler angles, rotational kinetic energy and angular momentum, the inertia tensor, Euler equations of motion, motion of a torque-free symmetrical top, stability of rotational motion.

**Recommended Books:**

1. T. Kibble and F. Berkshire, "Classical Mechanics", World Scientific, $5^{th}$ ed. (2004).

2. T. L. Chow, "Classical Mechanics", John Wiley, (1995).

3. S.T. Thornton, J.B. Marion, "Classical Dynamics of Particles and Systems", Brooks Cole; $5^{th}$ ed. (2003).

**PHY-354 ELECTRONICS I**

**Pre-requisite:** Modern Physics

**Credit Hours:** Three (3)

**Objectives:** To give an understanding of the basic electronics

**The semiconductor Diode:** Conductors, Insulators, and semiconductors; Silicon Crystal and Energy Band; Conduction in Silicon and Germanium; The forbidden energy gap; n and p type semiconductors; The junction diode; diode voltage- current equation; Zener diodes; Light emitting diodes; Photodiodes; Capacitance effects in the pn junction.

**The Diode as Rectifier and Switch:** The ideal and real diode models; The half wave rectifier; The Transformer; The full wave rectifier; The bridge rectifier; Measurement of ripple factor in the rectifier circuit; The capacitor filter; the ∏ filter; The ∏-R filter; The voltage doubling rectifier circuit; Diode wave clippers; Diode clampers.

**Circuit Theory and Analysis:** Basic circuit concepts; Superposition theorem; Thevenin's Theorem; Norton's Theorem; Model for circuit; one-port and two-port networks; Hybrid parameter equivalent circuit, Power in decibels.

**The Junction Transistor as an Amplifier:** Transistor voltage and current designations; The junction transistors; The volt-ampere curve of a transistor; The current amplification factors; The load line and Q point; The basic transistor amplifiers; The common emitter amplifier; The transconductance $g_m$; Performance of a CE amplifier; relation between $A_i$ and $A_V$; The CB amplifier; The CC amplifier; Comparison of amplifier performance.

**DC Bias for the Transistor:** Choice of Q point, variation of Q point, fixed transistor bias, the four resistor bias circuit, design of a voltage –feedback bias circuit, Common emitter, common collector, common base biasing

**Field Effect Transistor:** Field effect transistor (JFET); Static characteristics of JFET, Metal oxide semiconductor Field Effect Transistor (MOSFET of IGFET); Enhancement and depletion mode; FET biasing techniques; Common drain; common source and common gate; Fixed bias and self bias configurations; Universal JFET bias curve; Darlington pair.

**Operational Amplifiers:** The integrated amplifier; The differential amplifier; Common mode rejection ratio; The operational amplifier; Summing operation; Integration operation; Comparator; milli-voltmeter

**Recommended Books:**

1. J.D. Ryder, "Electronic Circuits and Systems", Prentice Hall (1976).
2. Thomas L. Floyd, "Electronics Fundamentals: Circuits, Devices and Applications", Prentice Hall, 8th ed. (2009).
3. Theodore F. Bogart, "Electric Circuits", McGraw Hill, (1992)
4. B. Grob, "Basic Electronics", MacGraw Hill, Tch ed. (1997).
5. A. P. Malvino, "Electronic Principles", McGraw Hill, 7th ed. (2006).
6. R. T. Paynter, "Introductory Electric Circuits", Prentice Hall, (1998)

**PHY-355 Lab-V(Electronics)**

**Credit Hours:** Two (2)

**Electronics:** DC voltages and current measurement, simple DC circuits, generating and analyzing time-varying signals, op-amps and comparators, amplifier design, RC transients, filters, frequency response, LC circuits, resonance, transformers, diodes, modulation and radio reception, MOSFET characteristics and applications, principles of amplification, bipolar transistors and amplifiers, digital logic circuits, gates and latches, D-flip flops and shift registers, JK flip-flops and ripple counters.

**Recommended Books:**

1. A. C. Melissinos and J. Napolitano, "Experiments in Modern Physics", Academic Press, 2nd ed. (2003).

2. J. H. Moore, C. C. Davis, M. A. Coplan, and S. C. Greer, "Building Scientific Apparatus", Cambridge University

Press, 4th ed. (2009).

3. J. R. Taylor, "An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements", University of Science Books, 2nd ed. (1996).

4. L. Kirkup and R. B. Frenkel, "An Introduction to Uncertainty in Measurement", Cambridge University Press, (2006).

5. G. L. Squires, "Practical Physics", Cambridge University Press, 4th ed. (2001).

6. Y. Tsividis, "A First Lab in Circuits and Electronics", John Wiley (2001).

**PHY-247 Research Methodology**

**Cr Hr 03**

Research and Types of research: Meaning of Research- Objectives of Research- Motivation in Research. Research methods vs Methodology. Types of research – Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical. Research Process. Criteria of good Research. Research Formulation – Defining and formulating the research problem - Selecting the problem - Necessity of defining the problem - Importance of literature review in defining a problem – Literature review – Primary and secondary sources, treatise, monographs-patents – web as a source – searching the web - Critical literature review – Identifying gap areas from literature review - Development of working hypothesis. Data Collection and analysis: Execution of the research - Observation and Collection of data - Methods of data collection – Modeling, Mathematical Models for research, Sampling Methods- Data processing and Analysis strategies. Data Analysis with Statistical Packages – Hypothesis-testing, Generalization-and Interpretation.

**Reference Books**:

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.

2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p. 3. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications. 2 volumes. 4. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.

5. Wadehra, B.L. 2000. Law relating to patents, trade marks, copyright designs and geographical indications. Universal Law Publishing.

**PHY-361 MATHEMATICAL METHODS OF PHYSICS-II**

**Pre-requisite:** Mathematical Methods of Physics-I

**Credit Hours:** Three (3)

**Objective(s):** To give the understanding of Differential equations and their uses in Physics, Introduction to special functions, Fourier Series, Fourier Transforms, Solution of Boundary value problems and their uses.

**Fourier Series and Integral Transforms:** Definition and general properties, Fourier Series of Various Physical Functions, Uses and Applications of Fourier Series, Fourier Transforms, Convolution Theorems, Laplace transforms and applications.

**Tensor Analysis:** Vector calculus (differentiation, integration, space curves, multi-variable vectors, surfaces, scalar and vector fields, gradient, divergence and curl, cylindrical and spherical coordinates, general curvilinear coordinates), change of basis, Cartesian tensor as a geometrical object, order/rank of a tensor, tensor algebra, quotient law, pseudo-tensors, Kronecker delta and Levi-cevita, dual tensors

**Group Theory and Representations for finite groups:** groups– definitions and examples, subgroups and Cayley's theorem, cosets and Lagrange's theorem, conjugate classes, invariant subgroups, factor groups, homomorphism, direct products, mappings, linear operators, matrix representations, similarity transformation and equivalent matrix representations, group representations, equivalent representations and characters, construction of representations and addition of representations, invariance of functions and operators, unitary spaces and Hermitian matrices, operators: adjoint, self-adjoint, unitary, Hilbert space, reducibility of representations.

**Recommended Books:**

1. G. Arfken, H. J. Weber, and F. E. Harris, "Mathematical Methods for Physicists", Academic Press, 7th ed. (2012).
2. E. Kreyszig, "Advanced Engineering Mathematics", John Wiley, 8th ed. (1999).
3. M. b and its Applications to Physical Problems", Dover Publications (1989).

**PHY-362 QUANTUM MECHANICS-I**

**Pre-requisites:** Modern Physics

**Credit Hours:** Three (3)

**Objective** To give a basic understanding of the quantum mechanics

**Waves and Particles: Introduction to the fundamental ideas of quantum mechanics:** Electromagnetic waves and photon, material particles and matter waves, quantum description of a particle, wave packets, particle in a time- independent scalar potential, order of magnitude of the wavelength associated with material particles, constraints imposed by uncertainty relations, one-dimensional Gaussian wave packet: Spreading of the wave packet, stationary states of a particle in one-dimensional square potential, behavior of a wave packet at a potential step

**The Mathematical Tools of Quantum Mechanics:** One-particle wave function space, state space, Dirac notation, representations in the state space, observable, representations, review of some useful properties of linear operators, unitary operators, study of the $\{|r\rangle\}$ and $\{|p\rangle\}$ representations, some general properties of two observables, *Q* and *P*, whose commutator is equal to $i\hbar$, the two-dimensional infinite well

**The Postulates of Quantum Mechanics:** Statement of the postulates and their physical interpretation, the physical implications of the Schrodinger equation, the superposition principle, particle in an infinite potential well, study of the probability current in some special case, root-mean-square deviations of two conjugate observables, the density and evolution operators, Schrodinger and Heisenberg pictures, Gauge invariance, bound states of a particle in a potential well of arbitrary shape, unbound states of a particle in the presence of a potential well or barrier of arbitrary shape, quantum properties of a particle in a one-dimensional periodic structure

**Application of the Postulates of quantum mechanics to Simple Cases: Spin ½ and Two-Level Quantum Systems:** Spin ½ particles, quantization of the angular momentum, illustration of the postulates in the case of a spin ½, general study of two level systems, Pauli matrices, diagonalization of a 2×2 Hermitian matrix, System of two spin ½ particles, Spin ½ density matrix, Spin ½ particle in a static magnetic field and a rotating field, Magnetic resonance

**The One-Dimensional Harmonic Oscillator:** Importance of the harmonic oscillator in physics, Eigen values and Eigen states of the Hamiltonian, mean value and root-mean-square deviations of $X$ and $P$ in state $|\varphi_n\rangle$, Some examples of harmonic oscillators, study of the stationary states in the $\{|r\rangle\}$ representation, Hermite polynomials, solving the Eigen values of the harmonic oscillators by the polynomial method, study of the stationary states in the $\{|p\rangle\}$ representation, isotropic three-dimensional harmonic oscillator, charged harmonic oscillator placed in a uniform electric field, coherent states, Normal vibrational modes of coupled harmonic oscillators, vibrational modes of an infinite linear chain of coupled harmonic oscillators, phonons, one-dimensional harmonic oscillator in thermodynamics equilibrium at a temperature $T$

**General Properties of Angular Momentum in Quantum Mechanics:** concept of angular momentum in quantum mechanics, commutation relations, application to orbital angular momentum, spherical harmonics, rotation operators, rotation of diatomic molecules, angular momentum of stationary states of a two-dimensional harmonic oscillator, charged particle in a magnetic field and Landau levels

**Particle in a Central Potential:** The Hydrogen atom, Stationary states of a particle in a central potential, motion of the center of mass and relative motion for a system of two interacting particles, Hydrogen atom, Hydrogen-like systems, A solvable example of a central potential: the isotropic three-dimensional harmonic oscillator, probability currents associated with the stationary states of the hydrogen atom, The hydrogen atom placed in a uniform magnetic field, paramagnetism and diamagnetism, Zeeman effect, study of some atomic orbitals, vibrational-rotational levels of diatomic molecules.

**Recommended Books:**

1. D. J. Griffiths, "Introduction to Quantum Mechanics", Addison-Wesley, 2nd ed. (2004).
2. R. Liboff, "Introductory Quantum Mechanics", Addison-Wesley, 4th ed. (2002).
3. N. Zettili, "Quantum Mechanics: Concepts and Applications", John Wiley, 2nd ed. (2009).

## PHY- 363 ELECTROMAGNETIC THEORY-II

**Electrodynamics II**

**Pre-requisites:** Electromagnetic Theory-I

**Credit Hours:** Three (3)

**Objective(s):** This course is the second part of the core level undergraduate course on Electromagnetic Theory and a previous knowledge of Electromagnetic Theory I is expected.

**Electrodynamics:** Electromotive force (emf): Ohm's law, electromotive force, motional emf, electromagnetic induction: Faraday's law, the induced electric field, inductance, energy in magnetic fields, Maxwell's equations:

electrodynamics before Maxwell, how Maxwell fixed Ampere's law, Maxwell's equations, magnetic charges, Maxwell's equations in matter, boundary conditions

**Conservation Laws:** Charge and energy: the continuity equation, Poynting's theorem, momentum: Newton's third law in electrodynamics, Maxwell's stress tensor, conservation of momentum, angular momentum

**Electromagnetic Waves:** Waves in one dimension: the wave equation, sinusoidal waves, boundary conditions, reflection and transmission, polarization, electromagnetic waves in vacuum: the wave equation for E and B, monochromatic plane waves, energy and momentum in electromagnetic waves, electromagnetic waves in matter: propagation in linear media, reflection and transmission at normal incidence, reflection and transmission at oblique incidence, absorption and dispersion: electromagnetic waves in conductors, reflection at a conducting surface, the frequency dependence of permittivity, guided waves: wave guides, the waves in a rectangular wave guide, the coaxial transmission line.

**Potentials and Fields:** The potential formulation: scalar and vector potentials, gauge transformations, Coulomb gauge and Lorentz gauge, continuous distributions: retarded potentials, Jefimenko's equations, point charges: Lienard-Wiechert potentials, the field of a moving point charge

**Radiation, Dipole Radiation:** Introduction to radiations, electric dipole radiation, magnetic dipole radiation, radiation from an arbitrary source, point charges: power radiated by a point charge, radiation reaction, the physical basis of the radiation reaction

**Electrodynamics and Relativity:** The special theory of relativity: Einstein's postulates, the geometry of relativity, the Lorentz transformations, the structure of space-time, relativistic mechanics: proper time and proper velocity, relativistic energy and momentum, relativistic kinematics, relativistic dynamics, relativistic electrodynamics: magnetism as a relativistic phenomenon, the field transformation mechanism, the field tensor, electrodynamics in tensor notation, relativistic potentials.

**Recommended Books:**

1. D. J. Griffiths, "Introduction to Electrodynamics", ed. Prentice Hall, 3rd ed. (1999).
2. M. N. O. Sadiku, "Elements of Electromagnetics", Oxford University Press, 5th ed. ed. (2009).
3. F. Melia, "Electrodynamics", University of Chicago Press, 1st ed. (2001).
4. J. Hearld and W. Muller-Kristen, "Electrodynamics", World Scientific Publishing, 2nd ed. (2011).

**PHY-364 ELECTRONICS-II**
**Pre-requisites: Electronics-I**
**Credit Hours: Three (3)**

**Amplifiers and their Frequency Response:** Cascade amplifier, The Amplifier pass band, The frequency plot, Low frequency plot, Low frequency limit, The un-bypassed emitter resistor, high frequency equivalent circuit, The Miller Effect, high frequency limit of transistor, bandwidth of a cascade amplifier.

**Feedback:** Positive and Negative feedback, Principle of feedback amplifier, stabilization of gain by negative feedback, Bandwidth improvement with negative feedback, Reduction of nonlinear distortion, control of amplifier output and input resistance, current series feedback circuit, voltage shunt feedback circuit.

**Oscillators:** Introduction, Classification of oscillators, Damped and un-damped oscillators, the oscillatory circuit, frequency stability of an oscillator, essentials of a feedback LC oscillator, tuned base oscillator, Hartley oscillator, Colpitis oscillator, crystal oscillator.

**Power Amplifiers:** Introduction, Power relation in class-A amplifiers, effect of thermal environment, determination of the output distortion, class-B amplifier, efficiency of class-A and class-B amplifiers.

**Modulation and Demodulation:** Introduction, carrier wave modulation, Need for modulation, radio Broadcasting, Methods of modulation, amplitude modulation, Forms of amplitude modulation, single

side band system of modulation, Diode for linear detector for amplitude modulation, High power level amplitude modulation, automatic volume control, Frequency modulation.

**Multivibrators:** Multivibrators, Basic types of Multivibrators, uses of Multivibrators, Astable Multivibrators, Mono-stable Multivibrators, Bi-stable Multivibrators, Schmitt Trigger Circuit.

**Integrated Circuits:** Introduction, Integrated circuit advantages and drawbacks, scale of integration, classification of integrated circuit by structure, Classification of integrated circuit by function, comparison between different integrated circuit. Integrated circuit terminology, Integrated circuit fabrication, Basic processing steps. Silicon device processes Silicon wafer preparation, diffusion, Oxidation photolithography, Scribing and separating into chips, Mounting and packing applications of integrated circuit.

**Digital Circuits:** Decimal, Binary, Octal, hexadecimal number systems, conversion of decimal numbers to any other number system and vice-versa, Binary codes, OR, AND, NOT, NAND, NOR logic gates, Boolean Algebra. Boolean expressions, simplification of Boolean expression using Boolean Algebra.

**Recommended Books:**

1. Thomas L. Floyd, "Electronics Fundamentals: Circuits, Devices and Applications", Prentice Hall, 8th ed. 2009.
2. B. Grob, "Basic Electronics", McGraw-Hill, Tch ed. 1997.
3. B. Streetman and S. Banerjee "Solid State Electronics Devices", Prentice Hall, 6th ed. 2005.
4. A. Bar-lev, "Semiconductor and Electronics Devices", Prentice Hall, 3rd ed.
1993.
5. D. H. Navon and B. Hilbert, "Semiconductor Micro-devices and Materials", CBS College Publishing, 1986.
6. A. P. Malvino, "Electronic Principles", McGraw-Hill, 7th ed. 2006.
7. R. T. Paynter, "Introductory Electric Circuits", Prentice Hall, 1998.

**PHY- 365 STATISTICAL MECHANICS**

**Pre-requisites:**Heat and Thermodynamics

**Credit Hours:** Three (3)

**Objective:** The main objective is to develop an understanding of the physical properties of the matter "in Bulk", on the basis of the Dynamic behaviour of its microscopic constituents.

**Review of Classical Thermodynamics:** Review of Thermodynamic Potentials; Chemical Potential; Phase Equilibria; Maxwell Relations

**Foundations of Statistical Mechanics:** Phase Space; Trajectories in Phase Space; Conserved Quantities and Accessible Phase Space; Macroscopic Measurements and Time Averages; Ensembles and Averages over Phase Space; Liouville's Theorem; The Ergodic Hypothesis; Equal a priori Probabilities; Specification of the state of a system; concept of ensembles; elementary probability calculations; distribution functions; statistical interpretation of entropy (Boltzmann theorem)

**Statistical Ensembles:** Phase Space; Specification of the State of a System; Statistical Ensembles; Probability Calculations and Density of States;

Micro-canonical ensemble; canonical ensemble and examples (e.g., paramagnet); calculation of mean values; calculation of partition function and its relation with thermodynamic quantities; the grand canonical ensemble and examples (e.g. adsorption); calculation of partition function and thermodynamic quantities

**Simple Applications of Ensemble Theory:** Monoatomic ideal gas in classical and quantum limit; Gibb's paradox and quantum mechanical enumeration of states; equipartition theorem and examples (ideal gas, harmonic oscillator); specific heat of solids; quantum mechanical calculation of paramagnetism

**Quantum Statistics:** Indistinguishability and symmetry requirements; Maxwell-Boltzmann statistics; Bose-Einstein and photon statistics; Fermi-Dirac statistics (distribution functions, partition functions); Examples: polyatomic ideal gas (MB), black body radiation (photon statistics), conduction electrons in metals (FD), Bose condensation (BE)

**Systems of Interacting Particles:** Lattice vibrations in solids; van der Waals gas; mean field calculation; ferromagnets in mean field approximation

**Recommended Books:**

1. F. Reif, "Fundamentals of Statistical and Thermal Physics", Waveland Pr Inc, (2008).
2. W. Brewer, F. Schwabl, "Statistical Mechanics", Springer, 2nd ed. (2006).
3. T. L. Hill, "Statistical Mechanics", World Scientific Publishing Company, (2004).
4. K. Huang, "Statistical Mechanics", John Wiley, 2nd ed. (1987).
5. A. J. Pointon, "Introduction to Statistical Physics", Longman (1967).

**PHY-366 Lab-VI(Advanced optics &spectroscopy)**

**Credit Hours:** Two (2)

**Modern Physics:** photoelectric effect, Frank-Hertz's quantization of energy levels, determination of Planck's constant (e.g. using a light bulb), verification of Moseley's law using X-ray fluorescence, Compton effect, Millikan's experiment for determination of charge of electron, properties of nuclear radiation (absorption in different media and response to external magnetic fields), statistical nature of radioactivity, determination of the half-life of radio-isotopes, Geiger-Muller tubes, cloud chambers, gamma rays spectroscopy, experiments on medical physics.

**Electronic Materials:** Measurement of electrical conductivity by two-probe and four-probe methods, band gap estimation of intrinsic and extrinsic semiconductors, carrier lifetimes and mobilities, Hall effect and its application in measuring magnetic fields, thermoelectric effects

**Recommended Books:**

1. A. C. Melissinos and J. Napolitano, “Experiments in Modern Physics”, Academic Press, 2nd ed. (2003).
2. J. H. Moore, C. C. Davis, M. A. Coplan, and S. C. Greer, "Building Scientific Apparatus", Cambridge University Press, 4th ed. (2009).
3. J. R. Taylor, "An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements", University of Science Books, 2nd ed. (1996).
4. L. Kirkup and R. B. Frenkel, “An Introduction to Uncertainty in Measurement”, Cambridge University Press, (2006).
5. G. L. Squires, "Practical Physics", Cambridge University Press, 4th ed. (2001).
6. Y. Tsividis, "A First Lab in Circuits and Electronics", John Wiley (2001).

**PHY- 471 QUANTUM MECHANICS-II**

**Pre-requisites:**QuantumMechanics-I

**Credit Hours:**Three (3)

**Objective(s):** This course is aimed at bridging the classical concepts with quantum mechanical concepts and will lead to the second part of the core level undergraduate course on quantum mechanics

**Addition of Angular Momenta:** Total angular momentum in classical mechanics, total angular momentum in quantum mechanics, addition of two spin ½ angular momenta, addition of two arbitrary angular momenta, Clebsch-Gordon coefficients, addition of spherical harmonics, vector operators, Evolution of two angular momenta *J1* and *J2* coupled by an interaction "*aJ1 . J2*".

**Stationary Perturbation Theory:** Description of the method, perturbation of a non-degenerate level, perturbation of a degenerate level, one-dimensional harmonic oscillator subjected to a perturbing potential, interaction between the magnetic dipoles of two spin ½ particles, Van der waals forces, volume effect and the influence of spatial extension of the nucleus on the atomic levels, variational method, energy bands of electrons in solids, a simple example of the chemical bond, $H_2$ion.

**Applications of Perturbation Theory to Atomic Systems:** Fine and hyperfine structure of atomic levels in hydrogen, Calculation of the mean values of the spin-orbit coupling in the 1*s*, 2*s* and 2*p* levels, hyperfine structure and the Zeeman effect for muonium and positronium, Stark effect

**Approximation Methods for Time-Dependent Problems:** Statement of the problem, approximate solution of the Schrodinger equation, An important special case: Sinusoidal or constant perturbation, Interaction of an atom with electromagnetic waves, linear and non-linear response of a two-level system subjected to a sinusoidal perturbation, Oscillations of a system between two discrete states under the effect of a resonant perturbation, Rabi flopping, decay of discrete state resonantly coupled to a continuum of final states, Fermi's golden rule

**Systems of Identical Particles:** Identical particles, Permutation operators, Symmetrization postulate, difference between bosons and fermions, Pauli's exclusion principle, many-electrons atom and their electronic configurations, energy levels of the helium atom, configurations, terms, multiplets, spin isomers of hydrogen (ortho- and para-hydrogen)

**Scattering by a Potential:** Importance of collision phenomena, Stationary scattering states, scattering cross section, scattering by a central potential, method of partial waves, phenomenological description of collisions with absorption.

**Recommended Books:**

1. D. J. Griffiths, "Introduction to Quantum Mechanics", Addison-Wesley, 2nd ed. (2004).
2. R. Liboff, "Introductory Quantum Mechanics", Addison-Wesley, 4th ed. (2002).
3. N. Zettili, "Quantum Mechanics: Concepts and Applications", John Wiley, 2nd ed. (2009).

**PHY-472 ATOMIC AND MOLECULAR PHYSICS**

**Pre-requisites:** Quantum Mechanics I

**Credit Hours:** Three (3)

**Objective(s):** To provide an introduction to the structure and spectra of atoms and molecules and to prepare students for more advanced courses on Physics of Atoms, Molecules and Photons

**One Electron Atoms:** Review of Bohr Model of Hydrogen Atom, Reduced Mass, Atomic Units and Wavenumbers, Energy Levels and Spectra, Schrodinger Equation for One-Electron Atoms, Quantum Angular Momentum 38 and Spherical Harmonics, Electron Spin, Spin-Orbit interaction. Levels and Spectroscopic Notation, Lamb Shift, Hyperfine Structure and Isotopic Shifts. Rydberg Atoms.

**Interaction of One-Electron Atoms with Electromagnetic Radiation:** Radiative Transition Rates, Dipole Approximation, Einstein Coefficients,Selection Rules, Dipole Allowed and Forbidden Transitions. Metastable Levels, Line Intensities and Lifetimes of Excited States, Shape and Width of Spectral Lines, Scattering of Radiation by Atomic Systems, Zeeman Effect, Linear and Quadratic Stark Effect.

**Many-Electron Atoms:** Schrodinger Equation for Two-Electron Atoms, Para and Ortho States, Pauli's Principle and Periodic Table, Coupling of Angular Momenta, L-S and J-J Coupling. Ground State and Excited States of Multi- Electron Atoms, Configurations and Terms.

**Molecular Structure and Spectra:** Structure of Molecules, Covalent and ionic Bonds, Electronic Structure of Diatomic Molecules, Rotation and Vibration of Diatomic Molecules, Born-Oppenheimer Approximation. Electronic Spectra, Transition Probabilities and Selection Rules, Frank- Condon Principle, H2+ and H2. Effects of Symmetry and Exchange. Bonding and Anti-bonding Orbitals. Electronic Spin and Hund's Cases, Nuclear Motion: Rotation and Vibrational Spectra (Rigid Rotation, Harmonic Vibrations). Selection Rules. Spectra of Triatomic and Polyatomic Molecules, Raman Spectroscopy, Mossbauer Spectroscopy.

## Recommended Books:

1. C. J. Foot, "Atomic Physics", Oxford University Press, 2005.

2. B. H. Bransden and C. J. Joachain, "Physics of Atoms and Molecules", Pearson Education, 2nd ed. 2008.

3. W. Demtroder, "Atoms, Molecules and Photons", y, Springer, 2nd ed. 2010.

4. C. N. Banwell and E. M. McCash, "Fundamentals of Molecular Spectroscopy", McGraw-Hill, 4th ed. 1994.

5. J. M. Hollas, "Basic Atomic & Molecular Spectroscopy", John Wiley, 2002.

### PHY-473 SOLID STATE PHYSICS-I

**Pre-requisites** Quantum Mechanics I, Statistical Mechanics

**Credit Hours:** Three (3)

**Objective:** This course will focus on collective quantum phenomena in solids, such as the emergence of physical phenomena from the interaction of a large number of atoms. It is designed to apply the previous knowledge of Physics to understand the crystal structure, thermal and electrical properties of solids and the Physics of these phenomena.

**Crystal Structure:** Lattices and basis; Symmetry operators; Fundamental Types of Lattice; Position and Orientation of Planes in Crystals; Simple crystal structures.

**Crystal Diffraction and Reciprocal Lattice:** Diffraction of X-rays, Neutron and electron diffraction from crystals; Bragg's law; Reciprocal lattice; Ewald Construction and Brillouin zone; Fourier Analysis of the Basis.

**Phonons and Lattice:** Quantization of Lattice Vibrations; Phonon momentum; Inelastic scattering by phonons; Lattice Vibrations for Mono-atomic and diatomic basis; Normal & Umklapp processes.

**Thermal Properties of Solids:** Lattice heat Capacity; Classical model; Enumeration of normal modes, Density of state in one, two or three dimensions, Einstein Model and Debye model of heat capacity; Comparison with experimental results; Thermal conductivity and resistivity;

**Electrical Properties of Metals:** Classical free electron theory of metals; Energy levels and density of orbital's in one dimension; Effect of temperature on the Fermi–Dirac distribution function; Properties of the free electron gas; Electrical conductivity and Ohm's Law; Thermal and electrical conductivities of metals and their ratio; Motion of free electrons in magnetic fields; Cyclotron frequency; Hall Effect along with applications.

**Recommended Books:**

1. C. Kittle, "Introduction to Solid State Physics", John Wiley, 8th ed. (2005).
2. M. A Omar, "Elementary and Solid State Physics", Pearson Education, (2000).
3. H. M. Rosenberg, "The Solid State", Oxford Science Publication, 3rd ed. (1988).
4. M. A. Wahab, "Solid State Physics", Narosa Publishing House, (1999).
5. N. W. Ashcroft and N. D. Mermin, "Solid State Physics", Rinehart & Winston (1976).
6. J.S. Blakemore, "Solid State Physics", Cambridge University Press, 2nd Ed. (1985).
7. S. R. Elliott, "The Physics and Chemistry of Solids", John Wiley (1998).

**PHY- 474 NUCLEAR PHYSICS**

**Pre-Requisites:** Modern Physics

**Credit Hours:** Three (3)

**Objective(s):** To understand the nuclear structure using different nuclear models, the nature of nuclear forces, radioactivity and nuclear reactions

**Basic Properties of Nucleus:** Nuclear size; mass; binding energy; nuclear spin; magnetic dipole and electric quadrupole moment; parity and statistics

**Nuclear Forces:** Yukawa's theory of nuclear forces; Nucleon scattering; charge independence and spin dependence of nuclear force; isotopic spin

**Nuclear Models:** Liquid drop model; Fermi gas model; Shell model; Collective model

**Theories of Radioactive Decay:** Theory of Alpha decay and explanation of observed phenomena; measurement of Beta ray energies; the magnetic lens spectrometer; Fermi theory of Beta decay; Neutrino hypothesis; theory of Gamma decay; multipolarity of Gamma rays; Nuclear isomerism

**Accelerators and detectors:** Van de Graph generator; linear accelerator; cyclotron; magnetron; Geiger-Muller counter; bubble chamber; cloud chamber; scintillator.

**Nuclear Reactions:** Conservation laws in nuclear reactions; Q-value and threshold energy of nuclear reaction; energy level and level width; cross sections for nuclear reactions; compound nucleolus theory of nuclear reaction and its limitations; direct reaction; resonance reactions; Breit-Wigner one level formula including the effect of angular momentum.

**Recommended Books:**

1. E. Segre, “Nuclei and Particles”, Benjamin-Cummings, 2nd ed. (1977).
2. I. Kaplan, “Nuclear Physics”, Addison-Wisely, (1980).
3. Green, “Nuclear Physics”, McGraw Hill, 1954.
4. K. S. Krane, “Introducing Nuclear Physics”, John Wiley, 3rd ed. (1988).
5. B. Povh, K. Rith, C. Scholtz, F. Zetsche, “Particle and Nuclei”, (1999).

**PHY- 475 Lab-VII**

**Credit Hours:** Two (2)

**Advanced Experiments:** nuclear magnetic resonance, electron spin resonance, Zeeman effect, optical pumping, lifetime of Muons, surface Plasmon resonance, Brownian motion, experiments with vacuum, low temperature physics, superconductivity, synthesis of nano-materials and their characterization, electromagnetically induced transparency, Mossbauer spectroscopy.

**Recommended Books:**

1. A. C. Melissinos and J. Napolitano, “Experiments in Modern Physics”, Academic Press, 2nd ed. (2003).
2. J. H. Moore, C. C. Davis, M. A. Coplan, and S. C. Greer, "Building Scientific Apparatus", Cambridge University Press, 4th ed. (2009).
3. J. R. Taylor, "An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements", University of Science Books, 2nd ed. (1996).

4. L. Kirkup and R. B. Frenkel, "An Introduction to Uncertainty in Measurement", Cambridge University Press, (2006).
5. G. L. Squires, "Practical Physics", Cambridge University Press, 4th ed. (2001).
6. Y. Tsividis, "A First Lab in Circuits and Electronics", John Wiley (2001).

**ELECTIVE-I**

**PHY-481 SOLID STATE PHYSICS - II**

**Pre-requisites:** Quantum Mechanics, Statistical Physics and Solid-State Physics I

**Credit Hours:** Three (3)

**Objective(s):** This course will focus on collective quantum phenomena in solids and has been designed to apply the previous knowledge of Physics to understand the electrical, optical and magnetic properties of solids. The knowledge obtained so for will be applied to understand the Physics of Semiconductors and Superconductivity.

**Dielectric Properties of Solids:** Polarization; Depolarization; Local and Maxwell field; Lorentz field; Clausius-Mossotti relation; Dielectric Constant and Polarizability; Measurement of dielectric constant; Ferro-electricity and ferroelectric crystals;

**Semiconductors:** General properties of semiconductors; Intrinsic and extrinsic semiconductors; Band structure; Carrier statistics in thermal equilibrium; Band level treatment of conduction in semiconductors and junction diodes; Diffusion and drift currents; Collisions and recombination times.

**Optical Properties:** Interaction of light with solids; Optical Properties of Metals and Non-Metals; Kramers-Kronnig Relation; Excitons; Raman Effect in crystals; Optical spectroscopy of solids.

**Magnetic Properties of Materials:** Magnetic dipole moment and susceptibility; Different kinds of magnetic materials; Langevin diamagnetism equation; Paramagnetic equation and Curie law; Classical and quantum approaches to paramagnetic materials; Ferro-magnetic and anti–ferromagnetic order; Curie point and exchange integral; Effect of temperature on different kinds of magnetic materials and applications.

**Superconductivity:** Introduction to superconductivity; Zero-Resistance and Meissner Effect; Type I and Type II superconductors; Thermodynamic fields; Two fluid model; London equations; BCS and Ginzburg–Landau Theory; Vortex Behaviour; Critical Current Density; Josephson effect and applications.

**Recommended Books:**

1. C. Kittle, "Introduction to Solid State Physics", John Wiley, 8th ed. (2005).
2. N. W. Ashcroft and N. D. Mermin, "Solid State Physics", Rinehart & Winston (1976).
3. G. Burns, "High Temperature Superconductivity - An Introduction", Academic Press (1992).
4. M. Fox, "Optical Properties of Solids", Oxford University Press, 2nd ed. (2010).
5. N. A. Spaldin, "Magnetic Materials: Fundamentals and Device Applications", Cambridge University Press, 2nd ed. (2010).

**ELECTIVE-III**

**Credit Hours:** Three (3)

Note: Any subject from the list for elective subjects below can be taken as Elective-III

**ELECTIVE-IV**

**Credit Hours:** Three (3)

Note: Any subject from the list for elective subjects below can be taken as Elective-IV

**PHY-482 PROJECT/THESIS**
**Credit Hours:** Three (3)

Note: Student must do a project in the last semester

## ELECTIVE COURSES IN BS PHYSICS

**These elective courses can be chosen from the list or new elective course may be offered according to the availability of staff and necessary infrastructure. The host institution may also tailor these courses according to their needs and available facilities.**

### PHY-476 ENVIRONMENTAL PHYSICS

**Credit Hours:** Three (3)

**Objective(s):** To become familiar with the essentials of environment and global climate and to learn the use ofspectroscopy for environmental study

**Introduction:** The human environment, Laws of thermodynamics, energy transfer, the green house effect and climate change.

**Basic Environmental Spectroscopy:** Electromagnetic spectrum, radiation from a black body, Lambert -Beer's Law, Radiative flux in the atmosphere, scattering and absorption of light by small particles, Rayleigh scattering, Mie scattering, Geometric scattering.

**Greenhouse gases and Global Climate change on Earth:** Energy balance, Anthropogenic $CO_2$ and other greenhouse gases, evidence for increase in the atmosphere. Aerosols and their properties, dynamics of aerosol population, climate change due to aerosols.

**Transport of Pollutants:** Diffusion and diffusion equation, dispersion of pollutant in rivers, ground water flow, Gaussian plumes in air, continental transport of pollutant.

**Sound and Noise:** Basic acoustics, measuring sound, propagation of sound over distance, human perceptions of sound and noise, noise level, controlling noise, active control of sound.

**Atmosphere and Radiation:** General laws of radiation, natural Radiation, solar and terrestrial radiation, energy balance for Earth and Atmosphere, solar variability, absorption of radiation by atmospheric gases.

**Atmosphere and Climate:** Structure of the atmospheres, vertical profiles in the lower layers of the atmospheres, lateral movements in the atmosphere, atmospheric circulation, cloud and fog formation, cloud types.

**Climatology and Measurements of Climate Factor:** Data collection and organization, statistical analysis of climatic data, general characteristics of measuring equipments, measurement of temperature, air humidity, surface wind velocity, radiation balance, precipitation, atmospheric pressure, automatic weather stations

Books Recommended:

1. B. Egbert and V. G. B. Rienk, Environmental Physics *ed. John Wiley and Sons* (1999)

2. Guyot Praxis Publication, Physics of Environmental and Climate (1998)

3. J. H. Seinfeld and S. N. Pandis, Atmospheric Chemistry and Physics: From Air Pollution to Climate Change. *John Wiley and Sons* (1998)

4. C. Smith, Environmental Physics. *Environment and Politics, 2nd ed.* (2001)

**PHY-477 METHODS OF EXPERIMENTAL PHYSICS**

**Pre-requisites:** Labs. I to VI.

**Credit Hours:** Three (3)

**Objective(s):** The objective of this course is to learn about the vacuum techniques and sensor technologies, the use of computer to acquire data from instruments and analysis of collected data.

**Vacuum Techniques:** Gas Transport; Throughput; Pumping Speed; Rotary pumps; Diffusion pumps; Sorption pumps; Production of ultrahigh vacuum; Fundamental concepts; Guttering pumps; Ion pumps; Cryogenic pumps; Turbo molecular pumps; Measurement of total pressure in Vacuums Systems; Units; Pressure ranges; Manometers; Pirani gauges; The McLeod gauges; Mass spectrometer for partial measurement of pressure; Design of high Vacuum system; Surface to Volume ratio; Pump Choice; Pumping system design; Vacuum Components; Vacuum valves; Vacuum Flanges; Liquid Nitrogen trap; Mechanical & Electrical feed through; Leak detection; Basic consideration; Leak detection equipment; Special Techniques and problems; Repair Techniques;

**Sensor Technology:** Sensors for Temperature; Heat; Pressure; Displacement; Rotation; Flow; Level; Speed; Position; Phase; Current; Voltage; Power; Magnetic field; Tilt; Metal; Explosive materials.

**Introduction to Computer Interfacing:** GPIB Interface; RS 232; DA/AD conversion; Visual c/visual Basic.

**Data Analysis:** Evaluation of measurement; Systematic Errors; Accuracy; Accidental Errors; Precision; Statistical Methods; Mean Value and Variance; Statistical Control of Measurements; Errors of Direct measurements; Rejection of data; Significance of results; Propagation of errors; Preliminary Estimation; Errors of Computation; Least squares fit to a polynomial; Nonlinear functions; Data manipulation; Smoothing; Interpolation and extrapolation; Linear and parabolic interpolation.

**Recommended Books:**

1. F. James, "Statistical Methods in Experimental Physics", World Scientific Company, 2nd ed. (2006).

2. M. H. Hablanian, "High-Vacuum Technology", Marcel Dekker, 2nd ed. (1997).

3. P. Bevington and D. K. Robinson, "Data Reduction and Error Analysis for Physical Science", McGraw Hill, 3rd ed. (2002).

4. S. Tavernier, "Experimental Techniques in Nuclear and Particle Physics", Springer, (2010).

5. J. B. Topping, "Errors of Observations and Their Treatment", Springer, 4th ed. (1972).

**PHY-478 COMPUTER SIMULATIONS IN PHYSICS**

**Pre-requisites:** Calculus-II, Linear Algebra, Probability and Statistics, Differential Equations, Introduction to Computing and Mechanics

**Credit Hours:** Three (3)

**Objective(s):** The aim is to develop one's ability to turn theoretical ideas of mathematics and physics into models speculated outcomes via computer simulations.

**Programming for Scientific Computation:** unix/linux basics, the editing-coding-compiling-debugging-optimizing- visualizing-documenting production chain, FORTRAN 95

**Numerical Programming:** Functions: approximation and fitting, Numerical calculus. Ordinary differential equations, Matrices, Spectral analysis, Partial differential equations **Modeling and Simulation:** Molecular dynamics simulations, Modeling continuous media Monte Carlo simulations

**Project:** A project will be chosen by the student in consultation with the instructor. Selection of the project should be done soon after the module on modelling and simulation starts and and continue over the course of the rest of the semester.

The final part of the course is reserved for presentation of preliminary and final results.

1. T. Pang, "An Introduction to Computational Physics", Cambridge University Press, (2008).

2. R. Landau, M. Paez, C. Bordeianu, "A Survey of Computational Physics", Princeton University Press, (2008).

**PHY-483 PLASMA PHYSICS**

Pre-requisite: Electromagnetic Theory-II, Waves and Oscillations

Credit Hours: Three (3)

## Objective(s):

To learn about the importance of the plasma along with the basic concept of plasma. To know fluid description of the plasma.

**Introduction**: Occurrence of plasma, Concept of temperature, Debye shielding, the plasma parameter, Criteria for plasma.

**Applications of Plasma Physics**: Single-particle motion in electromagnetic field, Uniform and non-uniform E and B fields, Time-variant E and B fields, Fluid description of plasma, Wave propagation in plasma, Derivation of dispersion relations for simple electrostatic and electromagnetic modes, Introduction to Controlled Fusion, Basic nuclear fusion reactions, Reaction rates and power density, radiation losses from plasma, operational conditions.

## Recommended Books:

1. F. F. Chen, "Introduction to Plasma Physics", 2nd ed. Plenum, 1995.

2. D. A. Gurnett and A. Bhattacharjee, "Introduction to Plasma Physics: with space and laboratory application", Cambridge University Press, 2005.

3. T. J. M. Boyd and J. J. Sanderson, "The Physics of Plasmas", Cambridge University Press, 2003.

**PHY-484 ELECTRONIC MATERIALS AND DEVICES**

**Pre-requisite:** Electronics-I, Optics

**Credit Hours:** Three (3)

**Objective(s):** To understand the relation between electrical, optical and magnetic devices

**Semiconductor Fundamentals:** Composition, purity and structure of semiconductors, energy bbers, density of states, the Fermi function and equilibrium distribution of carriers, doping, *n* and *p*-type semiconductors and calculations involving carrier concentrations, $E_F$ etc., temperature dependence of carrier concentrations, drift current, mobility, resistivity and band bending, diffusion and total currents, diffusion coefficients, recombination-generation, minority carrier life times and continuity equations with problem solving examples

**Device Fabrication Processes:** Oxidation, diffusion, ion implantation, lithography, thin-film deposition techniques like evaporation, sputtering, chemical vapour deposition (CVD), epitaxy etc.

***PN* Junction and Bipolar Junction Transistor:** Junction terminology, Poisson's equation, qualitative solution, the depletion approximation, quantitative electrostatic relationships, ideal diode equation, non-idealities, BJT fundamentals, Junction field effect transistor, MOS fundamentals, the essentials of MOSFETs

**Dielectric Materials:** Polarization mechanisms, dielectric constant and dielectric loss, capacitor dielectric materials, piezoelectricity, ferroelectricity and pyroelectricity

**Optoelectronic Devices:** Photoconductors, photovoltaics and photodetectors, photodiodes and photovoltaics, solar cell basics, LEDs, Lasers, displays, LCDs

**Magnetism and Magnetic Materials:** Basics of magnetism, hysteresis loops, magnetic domains and anisotropy, hard and soft magnetic materials, transformers, DC motors and data storage.

**Recommended Books:**

1. R. F. Pierret, "Semiconductor Device Fundamentals", Addison Wesley, 2nd ed. (1996).
2. N. Braithwaite, and G. Weaver, "Electronic Materials", MA: Butterworth, 2nd ed. (1990).
3. S. O. Kasap, "Electronic Materials and Devices", McGraw Hill, 3rd ed. (2005).
4. R. C. O'Handley, "Modern Magnetic Materials: Principles and Applications", Wiley Inter-Science, (1999).
5. D. Jiles, "Introduction to Magnetism and Magnetic Materials", Chapman & Hall, 2nd ed. (1998).

**PHY-485 INTRODUCTION TO MATERIAL SCIENCE**

**Pre-requisites:** Solid State Physics-I

**Credit Hours:** Three (3)

**Objective(s):** This course will explore important aspects of materials incorporating elements of applied physics and chemistry, relationship between the structure of materials at atomic or molecular scales and their macroscopic properties, defects and thermodynamics. The microstructure-mechanical properties relationship will be also addressed.

**Introduction:** Classification of Materials; Metals; Ceramics; Polymers; Composites; Semiconductors; Biomaterials; Smart and Nano-materials; Properties and Uses of these Materials.

**Atomic Structure of Materials:** The packing of atoms in 2-D and 3-D; Lattices and crystal systems in 3-D; Symmetry; Unit cells of the SC, BCC, FCC and HCP Crystal structure; Interstitial structures; Density computation; Indexing lattice directions and lattice planes; Interplanar spacing; Bragg's law and the intensities of Bragg reflections.

**Imperfections in Solids:** Vacancies; Impurities; Dislocations; Interfacial defects; Bulk or volume defects; Atomic vibrations.

**Thermodynamics and Phase Diagrams:** Microstructure and microscopy; One component phase diagrams; Pressure vs. temperature; Temperature vs. composition; Equilibrium; Thermodynamic functions; Gibbs free energy; Development of microstructure; Binary phase diagrams; Solidification; Diffusion mechanisms; Nucleation and growth of a new phase; Materials fabrication.

**Mechanical Behavior of Materials:** Normal stress and normal strain; Shear stress and shear strain; Elastic and plastic deformation; Young's modulus; Shear modulus; Poisson's ratio; Elastic strain energy; Yield stress, Dislocations and plastic deformation; Slip systems; Dislocations and strengthening mechanisms; Fracture mechanics; Ductile and brittle fracture; Griffith criterion; Ductile-brittle transition temperature; Cyclic stresses and fatigue; Creep.

**Recommended Books:**

1. W. D. Callister, "Materials Science and Engineering: An Introduction", Wiley, $7^{th}$ ed. (2006).
2. W. D. Callister and D. G. Rethwisch "Fundamentals of Materials Science and Engineering: An Integrated Approach", Wiley, $4^{th}$ ed. (2012).
3. J. F. Shackelford, "Introduction to Materials Science for Engineers", Prentice Hall, $7^{th}$ ed. (2008).
4. http://www.msm.cam.ac.uk/teaching/index.php,

**PHY-486 RENEWABLE SOURCES OF ENERGY**

**Credit Hours:** Three (3)

**Objectives:** To give students an understanding of the renewable energy resources

**Energy Scenarios**: Importance of energy, world primary energy sources, energy demand, supplies, reserves, growth in demand, life estimates, and consumption pattern of conventional energy sources: oil, gas, coal, hydro, nuclear etc. **Energy & Environment**: Emission of pollutants from fossil fuels and their damaging effects, and economics impact; Renewable energy and its sustainability. Renewable Scenarios: Defining renewable, promising renewable energy sources, their potential, availability, present status, existing technologies and availability.

**Solar Energy**: Sun-Earth relationship, geometry, sun path and solar irradiance, solar spectrum, solar constant, atmospheric effects, global distribution, daily and seasonal variations, effects of till angle, resource estimation, extraterrestrial, global, direct, diffused radiation, sun shine hours, air mass, hourly, monthly and annual mean, radiation on tilt surface, measuring instruments.

**Solar Thermal**: Flat plate collectors, their designs, heat transfer, transmission through glass, absorption transmission of sun energy, selective surfaces, performance, and efficiency; low temperature applications: water heating, cooking, drying, desalination, their designs and performance; concentrators, their designs, power generation, performance and problems. **Photovoltaics**: PV effect, materials, solar cell working, efficiencies, different types of solar cells, characteristics, (dark, under illumination), efficiency limiting factors, power, spectral response, fill-factor, temperature effect; PV systems, components, packing fraction, modules, arrays, controllers, inverters, storage, PV system sizing, designing, performance and applications.

**Wind**: Global distribution, resource assessment, wind speed, height and topographic effects, power extraction for wind energy conversion, wind mills, their types, capacity, properties, wind mills for water lifting and power generation, environmental effect.

**Hydropower**: Global resources, and their assessment, classification, micro, mini, small and large resources, principles of energy conversion; turbines, types, their working and efficiency for micro to small power systems; environmental impact. **Biogas**: Biomass sources; residue, farms, forest. Solid wastes: agricultural, industrial and municipal wastes etc; applications, traditional and non-traditional uses: utilization process, gasification, digester, types, energy forming, Environment issues. Resources availability; digester, their types, sizes, and working, gas production, efficiency; environmental effects;

**Geothermal**: Temperature variation in the earth, sites, potentials, availability, extraction techniques, applications; water and space heating, power generations, problems, environmental effects.

**Waves and Tides**: Wave motion, energy, potentials, sites, power extraction, and transmission, generation of tides, their power, global sites, power generation, resource assessment, problems, current status and future prospects.

**Hydrogen Fuel**: Importance of $H_2$ as energy carrier, Properties of $H_2$, production, hydrolysis, fuel cells, types, applications, current status and future prospects.

**Nuclear**: Global generations of reserves through reprocessing and breeder reactors, growth rate, prospects of nuclear fusion, safety and hazards issue.

**Energy Storage**: Importance of energy storage, storage systems, mechanical, chemical, biological, electrical, fuel cells etc.

**Recommended Books**

1. J. W. Twidell and A. D. Weir; Renewable Energy Resources; E & F.N. Spon. Ltd. London. (1986).

2. M. Iqbal; An Introduction to Solar Radiation: Academic Press, Canada. (1983).

4. S. Roberts, A Practical Guide to Solar Electricity, Prentice Hall Inc. USA, (1991).

5. M. A. Green; Solar Cells, Operating Principles, Technology, and system Application: Prentice Hall, Inc. USA, (1982).

6. T. J. Jansen, Solar Engineering Technology; Prentice Hall Inc. USA, (1985).

7. V. D. Hunt, Wind Power, A Book on Wind Energy Conversion System; Litton Educational Publishing Inc. (1981).

8. E. C. Price, P. N. Cheremisinoff; Biogas, Production and Utilization; Ann Arbor Science, USA, (1981).

9. I. Campbell, Biomass, Catalysts and liquid fuels; Technonic Publishing Co. Inc. USA, (1983).

**PHY-487 PARTICLE PHYSICS**

**Pre-requisites:** Quantum Mechanics-I

**Credit Hours:** Three (3)

**Objective(s):** In this course, one will learn about the concepts of Quantum Electrodynamics, Quantum Chromo- dynamics and related special topics to build up a strong base in theoretical physics.

**Introduction to Elementary Particles:** Fundamental building blocks and their interactions. Quantum Electrodynamics. Quantum Chromodynamics. Weak interactions. Decays and conservation laws

**Relativistic Kinematics:** Lorentz transformations. Four-Vectors. Energy and momentum. Particle collisions. Mandelstam variables

**Symmetries:** Symmetries and conservation laws, Spin and orbital angular momentum. Flavour symmetries. Parity. Charge conjugation. CP Violation. Time reversal and TCP Theorem

**Quantum Electrodynamics:** Klein-Gordon equation. Dirac equation. Solution of Dirac equation. Bilinear covariants.

Feynman rules for QED. Casimir's trick. Cross sections & lifetimes

**Neutrino Oscillations:** Solar neutrino problem. Oscillations, Neutrino masses. PMNS mixing matrix

**Gauge Field Theories:** Lagrangian in Relativistic Field Theory. Gauge Invariance. Yang-Mills Theory. The mass term. Spontaneous symmetry breaking. Higgs mechanism. Higgs boson. Grand Unification. Supersymmetry. Extra dimensions. String theory. Dark energy. Dark Matter.

1. D. J. Griffiths, "Introduction to Elementary Particles", Wiley-VCH, 2nd ed. (2008).

2. F. Halzen and A.D. Martin, "Quarks and Leptons: An introductory course in modern Particle Physics", John

Wiley, (1984).

3. D. H. Perkins, "Introduction to High-Energy Physics", Cambridge University Press, 4th ed. (2000).
4. V. D. Barger and R. J. N. Phillips, "Collider Physics", Addison-Wesley, (1996).

**PHY-488 INTRODUCTION TO NANO SCIENCE AND NANOTECHNOLOGIES**

**Pre-requisite:** Solid State Physics, Quantum Mechanics

**Credit Hours:** Three (3)

**Objective(s):** In this course, one will learn the importance of this interdisciplinary field, how such materials are developed atom by atom by incorporating the concepts and applications of nano-materials into nanotechnologies and how nanotechnology would be helpful to change our society in future.

**Introduction:** Feynman talks on small structures; Nano-scale; Nanotechnology in nature.

**Nano Materials:** Nanoparticles; Quantum dots; Nano-wires; Nano-tubes; Magnetic nano-structures; Nano thermal devices; Nano fluidic devices; Biomimetic materials;

**Quantum Effects:** Wave particle duality; Energy quanta; Uncertainty principle; De Broglie relation; Moore's law; Tunneling;

**Fabricating Nano-structures:** Solid state Reaction technique; Vapor deposition Method; Sol gel; Lithography (photo and electron beam); MBE; Self-assembly; Nano junctions; Thin Films; Sputtering; Self-assembled films

**Molecular Electronics:** Lewis structures; Approach to calculate; Molecular orbitals; Donor Acceptor properties; Electron

transfer between molecules; Charge transport in weakly interacting molecular solids; Single molecule electronics; Single electron transistor; Resonant tunneling;

**Nano Biotechnology:** DNA micro-arrays; Protein and DNA Assembly; Digital cells; Genetic circuits; DNA computing; **Characterization Techniques:** XRD; Electron Microscopy (STM, AFM, SEM and TEM); Fluorescence methods; Synchrotron Radiation;

**Nanotechnology the Road Ahead:** Nanostructure innovation, Quantum Informatics, Energy solutions.

1. B. Bhushan, "Springer Hand Book of Nanotechnology", 3rd Edition, Springer Berlin Heidelberg, (2010).

2. C. Binns, "Introduction to Nanoscience and Nanotechnology (Wiley Survival Guides in Engineering and Science)", Wiley, (2010).

3. S. Lindsay, "Introduction to Nanoscience", Oxford University Press, (2009).

4. S.C. Tjong, Nano-crystalline Materials: Their synthesis-Structure-property Relationship and Applications, Elsevier,2006.

5. Y.Gogotsi (Editor), Nano-Materials Hand Book, CRC Press, Taylor & Francis Group, (2006).

6. M.J. Schulz, A.D. Kelkar and M.J. Sundaresan (Editors), Nano-engineering of structural, Functional and Smart Materials, CRC Press, Taylor & Francis Group, (2006).

**PHY-489 LASER APPLICATIONS**

**Pre-requisites:** Introduction to Laser Physics

**Credit Hours:** Three (3)

**Objective(s):** This course is designed to introduce the major applications of lasers in different fields of science and technology

**Fundamentals of Lasers:** Review of the working principles of a laser; Laser Resonators and Modes; Q-switching; Mode- locking; Ultrafast pulse generation; Fixed Frequency and Tunable Lasers

**Characteristics of Laser Light:** Laser wavelength**;** CW and pulsed modes**;** Laser power; energy per pulse; pulse duration; repetition rate; frequency width; beam divergence

**A Survey of Laser Sources**: Brief descriptions of solid-state lasers; gas lasers; semiconductor lasers; dye lasers; excimer lasers; metal vapor lasers; fiber lasers

**Applications of Low-Power Lasers**: Scanning; Alignment; Surface Monitoring; Position and Velocity Measurements; Laser Interferometry; Laser Radar**;** Environmental Applications

**Applications of High-Power Lasers:** Laser Material Processing including Cutting; Drilling; Trimming; Welding; Marking and Surface Treatment; Surface Cleaning and Decontamination; Laser Ultrasonic, Laser Produced Plasmas and Laser Fusion

**Laser Applications based on Frequency Resolution:** Photo-physical and Photo-chemical Processes; Laser Isotope

Separation; Laser Enhanced Chemical Reactions **Laser Applications based on Time Resolution:** Laser Radar; Ultrafast Processes

**Optical Communications, Data Storage and Processing:** Fiber Optics; High Speed Communication; Optical Holography; Optical Computers

**Medical Applications:** Ophthalmology; Dermatology; Photodynamic Therapy; Dentistry; Microsurgery

**Military Applications:** Ranging and Tracking; Target Designation; Guidance System; Directed Energy Weapons

**Lasers in Scientific Research:** Laser Spectroscopy

**Laser Safety:** Eye and Skin Hazards, Electrical and Chemical Hazard

**Recommended Books:**

1. K. R. Nambiar, “LASERS: Principles, Types and Applications”, New Age, (2009).
2. K. Thyagarajan, “Lasers: Fundamentals and Applications”, Springer, 2nd ed (2010).
3. J. F. Ready, "Industrial Applications of Lasers", Academic Press, 2nd ed. (1997).
4. W. M. Steen, J. Mazumder and K. G. Watkins, “Laser Material Processing”, Springer, 4th ed. (2010).
5. W. T. Silfvast, “Laser Fundamentals”, Cambridge, 2nd ed. (2008)