

PHYSICS

For Class XI

The question paper of Physics for Class XI will be based on the SLOs of the following units:

- 1. MEASUREMENT**
- 2. VECTORS AND EQUILIBRIUM**
- 3. FORCES AND MOTION**
- 4. WORK AND ENERGY**
- 5. ROTATIONAL AND CIRCULAR MOTION**
- 6. FLUID DYNAMICS**
- 7. OSCILLATIONS**
- 8. WAVES**
- 9. PHYSICAL OPTICS**
- 10. THERMODYNAMICS**

PHYSICS

For Class XII

The question paper of Physics for Class XII will be based on the SLOs of the following units:

- 11. ELECTROSTATICS**
- 12. CURRENT ELECTRICITY**
- 13. ELECTROMAGNETISM**
- 14. ELECTROMAGNETIC INDUCTION**
- 15. ALTERNATING CURRENT**
- 16. PHYSICS OF SOLIDS**
- 17. ELECTRONICS**
- 18. DAWN OF THE MODERN PHYSICS**
- 19. ATOMIC SPECTRA**
- 20. NUCLEAR PHYSICS**

National Curriculum for

PHYSICS

Grades XI – XII

2006

GOVERNMENT OF PAKISTAN
MINISTRY OF EDUCATION
ISLAMABAD



National Curriculum for
PHYSICS
Grades XI – XII
2006



GOVERNMENT OF PAKISTAN
MINISTRY OF EDUCATION
ISLAMABAD

List of Contents

Sr. No.	Content	Page
1.	Part-I Preamble	1
2.	Introduction	1
3.	Rationale	1
4.	Curriculum Development Stratagem	2
5.	Need Assessment	2-3
6.	Comparative Studies with International Curricula	4-5
7.	Part-II Contents	6
8.	Vision Statement	6
9.	Aims	6
10.	Syllabus Design	6-7
11.	Standards, Benchmarks and Learning Outcomes	7-8
12.	Physics Standards and Benchmarks for Grades IX-XII	8-12
13.	Unit # 1 Measurement	13-14
14.	Unit # 2 Vectors and Equilibrium	15-16
15.	Unit # 3 Forces and Motion	17-19
16.	Unit # 4 Work and Energy	20-21
17.	Unit # 5 Rotational and Circular Motion	22-23
18.	Unit # 6 Fluid Dynamics	24-25
19.	Unit # 7 Oscillations	26-27
20.	Unit # 8 Waves	28-29
21.	Unit # 9 Physical Optics	30-31
22.	Unit # 10 Thermodynamics	32-33
23.	Unit # 11 Electrostatics	34-35
24.	Unit # 12 Current Electricity	36-37
25.	Unit # 13 Electromagnetism	38-39
26.	Unit # 14 Electromagnetic Induction	40-42
27.	Unit # 15 Alternating Current	43-45

28.	Unit # 16 Physics of Solids	46-47
29.	Unit # 17 Electronics	48-49
30.	Unit # 18 Dawn of the Modern Physics	50-51
31.	Unit # 19 Atomic Spectra	52-53
32.	Unit # 20 Nuclear Physics	54-56
33.	Objectives of Practical Work	57-58
34.	List of Practical for grade XI	59-60
35.	List of Practical for gradeXII	61-62
36.	List of required apparatus / equipment for grade XI	63-64
37.	List of required apparatus / equipment for grade XII	65-66
38.	List of required apparatus/equipment for standard experiments and exercises Physics for grades XI-XII (for a group of 40 students)	67-69
39.	Estimated Time allocation and Weighting for various Units/chapters	70
40.	Assessment Objectives	71-72
41.	Glossary of Terms Used in Physics Papers	73-74
42.	Assessment Pattern XI-XII (Physics)	75-76
43.	Assessment Methods	76-78
44.	Part-III Instructions and Suggestions	79
45.	Guidelines to Textbook Authors	79-80
46.	Teaching Strategies/Methodologies	81-88
47.	Professional Development of Teachers	89-90
48.	Part-IV Salient Features – Physics Curriculum 2006	91-92
49.	National Curriculum Development Team	93

PART-I

PREAMBLE

INTRODUCTION

The course in physics lays stress on the development of scientific temper, the cultivation of social, ethical, moral and aesthetic values and development of sensitivity to possible uses and misuses of science and concern for clean and sustainable environment.

The study of physics involves the students working individually and with others in active, practical, field and interactive media experiences that are related to the theoretical concepts considered in the course. It is expected that students studying physics will apply investigative and problem-solving skills, effectively communicate the theoretical concepts studied in the course and appreciate the contribution that study of physics makes to our understanding of the world.

An understanding of physics, and the development of new applications of this understanding, will help students to appreciate the factors that influence the pursuit of science and have a significant impact on the way people live. Physics, therefore, contributes to people's understanding and appreciation of the natural world and to their ability to make informed decisions about technological applications.

RATIONALE

Academic knowledge and rapid technical advancement during the era of globalization has caused tremendous changes in the national and international social and economical spheres. These changes necessitate revision of the national education curriculum which is a fundamental mechanism for the development of national education quality. Need has been realized to restructure the curriculum so that the abilities and skills of inquiry becomes the vehicles for acquiring scientific knowledge.

The structure of the syllabus is based on logical sequencing of the subject matters kept by proper placement of the concepts, appropriate to the comprehension level of students. Due care has been taken that the syllabus is not heavy and at the same time, it is comparable to the international standards. Curriculum load has been reduced by eliminating overlapping of concepts within the discipline of physics or with other disciplines making room for contemporary core topics and emerging curricular areas. The scientific method has been practiced as a method of inquiry in a way that stimulates curiosity and interest. Every opportunity has been taken to expose the students to the applications of physics to technology and environmental issues. Emphasis has been to promote process-skills, problem-solving abilities and application of concepts, useful in real life situations for making Physics learning more relevant, meaningful and interesting.

CURRICULUM DEVELOPMENT STRATAGEM

1. Formation of Curriculum Development Team comprising of Experts from diverse areas of education such as Subject Specialists of Punjab Textbook Board, former Curriculum Research & Development Centre (CRDC), Provincial Institute of Teacher, Education (PITE), Directorate of Staff Development (DSD), Teachers, Educators, Working School and College Teachers of public schools as well as of private schools.
2. Orientation and training workshops/seminars on curriculum development.
3. Consultative meeting with students / working teachers, professors to get feedback and comments on existing curriculum.
4. The need assessment by critically reviewing of current curriculum, extensive field survey to seek feedback/ comments from students, teachers and other stakeholders.
5. Analysis of feedback received by Punjab Textbook Board and Curriculum Wing, Islamabad.
6. Downloading of 18 international curriculum documents from the internet/websites.
7. Study of foreign curricula for comparison and guidelines.
8. Determination of philosophy of curriculum design, aims and objectives, standards and benchmarks.
9. Drafting of core syllabus: The structure, units, contents, learning outcomes with time frame and weighting including identification of investigations / practicals and demonstrations, assessment pattern.
10. Drafting suggestions on the other components of curriculum such as
 - (a) Instructions for writing teaching-learning materials/ textbooks,
 - (b) Teaching strategies and methodology
 - (c) Teachers training
11. Identification of salient features of National Physics Curriculum Draft.

NEED ASSESSMENT

The necessity to revise and update physics curriculum is based on the aspirations of our Government and the people visualizing a vibrant and responsive curriculum comparable with international standards. A curriculum which can meet the challenges of the era of knowledge driven economies as well as grooming the younger generation into dynamic, responsible and productive citizens of this technological world.

The feedback received in the Punjab Textbook Board during the last three years on the curriculum and course material in vogue is another factor supporting the same cause. In addition to that an extensive field survey for the purpose of need assessment was carried out to seek comments and suggestions on physics curriculum from the students, teachers and other stakeholders.

Data about the modern trends in the process of curriculum revision, the world over, were downloaded and analyzed. Newspaper articles, columns and reports were also collected to ensure a reflexive involvement of stakeholders.

The following field study reports were carefully examined and analyzed before launching work on the draft curriculum

- 1 Feedback analysis from Field Survey of the following colleges by Mr. C.D. Arif, Additional Director (Curriculum Wing), Punjab Textbook Board.
 - (a) Govt. College of Science, Wahdat Road, Lahore
 - (b) Govt. College for Women, Bund Road, Lahore
 - (c) Pak Polytechnique Allama Iqbal Town, Lahore
- 2 Critical Review of National Curriculum Physics XI-XII (2000) by Mr. Majahid Haider, Beaconhouse School System.
- 3 Critical Review of National Curriculum Physics XI-XII (2000) by Mrs. Nazma Sheikh, S.S.S. (Physics), Punjab Textbook Board, Lahore.
- 4 Feedback from Students and Teachers Crescent Model School Lahore by Mr. M. Shakoor, Headmaster.
- 5 Feedback from students and teachers by Mr. Muhammad Ismail Zareef, Crescent Model Higher Secondary School, Lahore.

The committee identified the following focussing areas:

1. Elimination of vertical overlapping within the discipline and horizontal overlapping with other disciplines.
2. Linkage to be established horizontally with other disciplines and vertically within the discipline.
3. Modern trends and development to be incorporated.
4. Relevance of concepts with students own experience, observations and environment.
5. Identification of re-sequencing of some concepts.
6. Provision of conducive environment for enjoyable and thrilling learning experiences.
7. Stimulating students curiosity and sense of wonder.

8. Developing, observing, measuring, performing and recording skills in a context that enables students to experience the joy of doing physics.
9. Emphasis on real life applications of concepts and problem solving techniques.
10. More emphasis on in-depth understanding of a concept rather than breadth.

Need has been realized to restructure the curriculum in the light of above study reports/feedback so that the thinking abilities and skills becomes the vehicle for acquiring scientific knowledge, investigating and problem solving techniques.

COMPARATIVE STUDIES WITH INTERNATIONAL CURRICULA

The Physics Curriculum Team carried out comparative studies of National Curriculum in vogue with the following international curricula before initiating drafting of National Curriculum:

- 1 Physics GCE “A” Level 2007, University of Cambridge International Examinations (CIE), U.K.
- 2 Physics Syllabus, Malta
- 3 Physics Curriculum Secondary Level, Hong Kong
- 4 NBSE Physics Curriculum of India for classes XI-XII
- 5 Grades Nine through twelve – Physics, California State Board of Education, U.S.A.
- 6 Physics Curriculum Guidelines of Ontario, Canada
- 7 South Australia Certificate of Education Physics Curriculum 2006
- 8 New South Wales Australia Physics Curriculum 2002

The following international curriculum documents were also downloaded and consulted before initiating work on the draft curriculum:

- 1 National Science Curriculum Standards, The Institute for the Promotion of Teaching Science and Technology, Thailand
- 2 NEBRASKA Science Standards Grades K-12
- 3 Star Science Standards, Nebraska Department of Education
- 4 Physics Secondary School Curriculum, State of Utah
- 5 Michigan State Board of Education Standards and draft Benchmarks (summer 2000)
- 6 Sequoia Union High School District Physics Curriculum Guide (U.S.A.)

- 7 Mississippi Science Framework 2001 U.S.A.
- 8 Science Curriculum Reforms in U.S.A.
- 9 Coal city High School Physics Curriculum, U.S.A.
- 10 San Ramon Valley Unified School District 2002 Physics Curriculum Grades 9-12, U.S.A.
11. The University of the Punjab Syllabus for B.Sc. classes.

PART-II CONTENTS

VISION STATEMENT

Promotion of process skills, problem solving abilities and application of concepts, useful in real life situation for making physics learning more relevant, meaningful and stimulating.

AIMS

The Aims of Physics at higher secondary level are to enable student to:

- Develop among the students the habit of scientific and rational thinking and an attitude to search for order and symmetry in diverse phenomena of nature and thereby to appreciate the supreme wisdom and creative powers of the creator.
- Become life long learner, effective problem solver, responsible and productive citizens in a technological world.
- Strengthen the concepts developed at the secondary level to lay firm foundation for further learning of physics at the tertiary level, in engineering or in other physics dependent and vocational courses.
- Develop process skills and experimental, observational, manipulative, decision making and investigatory skills in the students.
- Understand and interpret scientific information presented in verbal, mathematical or graphical form and to translate such information from one form to another.
- Understand and appreciate the inter relationship and balance that exists in nature, the problems associated with the over exploitation of the environmental resources and disturbance because of the human activities in the ecological balance, thus taking care of the environment.

SYLLABUS DESIGN

The syllabus is designed to emphasize less on purely factual material, but a much greater emphasis on the understanding and application of physics concepts and principles. This approach has been adopted in recognition of the need for students to develop skills that will be of long term value in an increasingly technological world.

The syllabus framework is based on the **standards and benchmarks** framed by National Curriculum Council. It comprises of twenty units with overview of each unit.

In order to specify the syllabus as precisely as possible and also to emphasize the importance of higher order abilities and skills other than recall, **learning outcomes** have been used throughout. Each unit of the syllabus is specified by **content section/major concepts** followed by detailed **learning outcomes**. The intended level and scope of treatment of a content is defined by the stated **learning outcomes** with easily recognizable domain of (i) **recalling** (ii) **understanding** (iii) **applying** (iv) **analyzing** (v) **evaluating** (vi) and **creating**. Under the subhead “**skills**”

measuring, observing, manipulating, recording and interpreting /analyzing, predicting and **communicating abilities/ skills** are expected to be developed through related **investigations, activities and practical work**.

The relevance and significance of concepts to students everyday life and to the natural and man made world is given under the subhead “**science, technology and society connections**”. This section preferably be delivered through novel questions or numerical problems based on real life experiences. The applications which are slightly of higher level may be tackled through guided inquiry approach.

Unit-wise weighting and time allocation for each chapter has been proposed. A separate list of standard practicals, and required equipment is given. Assessment pattern has also been included in the curriculum document.

STANDARDS, BENCHMARKS & LEARNING OUTCOMES

In the 21st century, students will remain the most important natural resource to ensuring the continual improvement and ultimate progress of humankind. It is critical that all involved in education prepare students to meet the challenges of a constantly changing global society. It is time to call for a raising in the expectations of student learning.


Preparing students for success in the new millennium and beyond, calls for increasing rigor and relevance in the curriculum. In adult roles, individuals are expected to work with others in a team setting, have an acquired knowledge base, be able to extend and refine knowledge, be able to construct new knowledge and applications and have a habit of self-assessing their assimilation of each dimension in their everyday decision making process.


This curriculum document is built upon Standards, Benchmarks, and Learning Outcomes for the benefit of student growth and progress.

STANDARDS are what students should know and be able to do. Standards are broad descriptions of the knowledge and skills students should acquire in a subject area. The knowledge includes the important and enduring ideas, concepts, issues, and information. The skills include the ways of thinking, working, communication, reasoning, and investigating that characterize a subject area. Standards may emphasize interdisciplinary themes as well as concepts in the core academic subjects.

Standards are based on:

- 🔔 **Higher Order Thinking**: instruction involves students in manipulating information and ideas by synthesizing, generalizing, explaining or arriving at conclusions that produce new meaning and understanding for them.
- 🔔 **Deep Knowledge**: instruction addresses central ideas of a topic or discipline with enough thoroughness to explore connections and relationships and to produce relatively complex understanding.

 *Substantive Conversation*: Students engage in extended conversational exchanges with the teacher and / or peers about subject matter in a way that builds an improved and shared understanding of ideas or topics.

 *Connections to the World Beyond the Classroom*: Students make connections between substantive knowledge and either public problems or personal experiences.

BENCHMARKS indicate what students should know and be able to do at various developmental levels. Our benchmarks are split into 5 developmental levels:

- Kachi to grade 3
- Grade 4 to Grade 5
- Grade 6 to Grade 8
- Grade 9 to Grade 10
- Grade 11 to Grade 12

LEARNING OUTCOMES indicate what students should know and be able to do for each topic in any subject area at the appropriate developmental level. The Learning Outcomes sum up the total expectations from the student. Within this document the Learning Outcomes are presented under three subheadings:

- ⚙ Understanding
- ⚙ Skills including laboratory work
- ⚙ Science, Technology and Society connections

The Standards and the accompanying Benchmarks will assist in the development of comprehensive curriculum, foster diversity in establishing high quality Learning Outcomes, and provide an accountability tool to individuals involved in the education market place. These provide a common denominator to determine how well students are performing and will assure that all students are measured on the same knowledge and skills using the same method of assessment.

PHYSICS STANDARDS AND BENCHMARKS FOR GRADES IX-XII

The content standards provide descriptions of what students should know, understand and be able to do in a specific content area.

In addition, benchmarks in each content areas are drafted to further clarify the content standards. They define our expectations for students knowledge, skills and abilities along a development continuum in each content area. They are meant to define a common denominator to determine how well students are performing.

(A) Constructing New Scientific Knowledge

Scientifically literate students are learners as well as user of knowledge. They ask question about the world that can be answered by using scientific knowledge and techniques. They can also develop solutions to problems that they encounter or

questions they ask. They can remember key points and use sources of information to reconstruct previously learnt knowledge, rather than try to remember every detail of what they learnt.

Standard 1.

Students will be able to display a sense of curiosity and wonder about the natural world and demonstrate an increasing awareness that this has led to new developments in science and technology.

(B) Reflecting on scientific knowledge

Scientifically literate students can show an appreciation for scientific knowledge and the patterns that reveal in the world; this often involves seeing connections among different areas of knowledge. They may be able to take a historical and cultural perspective on concepts and theories or to discuss relationships among science, technology and society.

Standard 2.

Students will be able to demonstrate an understanding of the impact of science and technology on society and use science and technology to identify problems and creatively address them in their personal, social and professional lives.

(C) Using scientific knowledge

Scientifically literate students can use their knowledge to understand the world around them and to guide their actions. Important type of activities that use scientific knowledge include description and explanation of real world objects, systems or events; prediction of future events or observations; and the design of systems or courses of action that enable people to adopt to and modify the world around them.

Standard 3.

Student will be able to understand the processes of scientific investigation. They will be able to identify a problem, design and conduct experiments and communicate their findings using a variety of conventional and technological tools.

Standard 4.

Students will be able to describe and explain common properties, forms and interactions of energy and matter, their transformations and applications in physical systems.

BENCHMARKS

Standard Code	Benchmarks Secondary Level	Benchmarks Higher Secondary Level
	At the end of the course, the students will:	At the end of the course, the students will:
1.1	Generate scientific questions about the world based on observation.	Ask questions that can be investigated empirically.
1.2	Develop solutions to problems through reasoning, observation, and investigations.	Develop solutions to problems through reasoning, observation, and investigations.
1.3	Design and conduct scientific investigations	Design and conduct scientific investigations.
1.4	Use tools and equipment appropriate to scientific investigations.	Recognize and explain the limitations of measuring devices.
1.5.	Use metric measurement devices to provide consistency in an investigation.	Gather and synthesize information from books and other sources of information.
1.6	Use sources of information in support of scientific investigations.	–
1.7	Write and follow procedures in the form of step-by-step instructions, formulae, flow diagrams, and sketches.	Discuss topics in groups by making clear presentations, restating or summarizing what others have said, asking for clarification or elaboration, taking alternative perspectives, and defending a position.
2.1	Evaluate the strengths and weaknesses of claims, argument or data.	Justify plans or explanations on a theoretical or empirical basis.
2.2.	Describe limitations in personal knowledge.	Describe some general limitations of scientific knowledge.
2.3	Show how common themes of science, mathematics, and technology apply in real-world contexts.	Show how common themes of science, mathematics, and technology apply in real world contexts.
2.4	–	Discuss the historical development of the key scientific concepts and principles.
2.5	Describe the advantages and risks of new technologies	Explain the social and economical advantages and risks of new technology.
2.6	Develop an awareness and sensitivity to the natural world.	Develop an awareness and sensitivity to the natural world.

2.7	Recognize the contributions made in science by cultures and individuals of diverse backgrounds.	Describe the historical, political and social factors affecting developments in science.
3.1	Understand inquiry principles and process of 1 st hand investigation in Physics.	Appreciate the ways in which models, theories and laws in physics have been tested and validated
3.2	Describe applications of physics which affect society or the environment.	Assess the impacts of applications of physics on society and the environment.
3.3	Select and use appropriate equipment for investigation plan.	Justify the appropriateness of a particular investigation plan.
3.4	Identify methods, collecting and recording data, and also organizing and analyzing data.	Identify ways in which accuracy and reliability could be improved in investigations.
3.5	Use appropriate terminology and reporting styles to communicate information and understanding in physics.	Use terminology and report styles appropriately and successfully to communicate information.
3.6	Draw valid conclusions from gathered data and information.	Assess the validity of conclusions from gathered data and information.
4.1	Describe the forces acting on an object which causes changes in its motion.	Explain events in terms of Newton's laws and law of conservation of momentum.
4.2	Describe the effects of energy transfers and energy transformations.	Explain the effects of energy transfers and energy transformations.
4.3	Describe modular model of matter and its understanding to explain various concepts related the behaviour of matter.	Explain mechanical, electrical and magnetic properties of solids and their significance.
4.4	Demonstrate an understanding of the principles related to fluid statics and appreciate their use in hydraulic systems.	Demonstrate an understanding of the principles related to fluid dynamics and their applications.
4.5	Investigate and explain heat transfers by conduction, conversion and radiation and their consequences.	Explain that heat flow and work are two forms of energy transfers between systems and their significance.
4.6	Explain wave motions in terms of energy sources and the oscillations produced.	Understand wave properties, analyze wave interactions and explain the effects of those interactions.

4.7	Show understanding of geometrical optics by experimenting and exploring reflection and refraction of light and make use of them in spherical mirrors and lenses.	Demonstrate an understanding of wave model of light as e.m waves and describe how it explains diffraction patterns, interference and polarization.
4.8	Describe the relationship between force and potential energy in gravitational and electrical fields.	Explain the effects of electric, magnetic and gravitational fields.
4.9	Show understanding of electric current and potential difference and calculate electric energy consumption of appliances and demonstrate safety measures in home circuitry.	Demonstrate and understand the properties, physical quantities, principles and laws related to electricity and magnetism and make use of them.
4.10	Investigate and state basic properties of some electronic and communication components and make basic electronic circuit and make use of it.	Investigate and explain basic properties of semi-conductors devices (diodes and transistors) and make electronic circuits and make use of them.
4.11	Describe and explain the structure of atom and atomic nucleus, origin of radioactivity, its uses and hazards.	Search, for information and explain nuclear reactions, fission, fusion, interaction between matter and energy benefits and risks of nuclear energy. Describe quantum theory, special theory of relativity and other modern concepts in Physics.

Unit - 1 Measurement

Overview: Scientific investigation require precise and accurate measurement of physical quantities in appropriate units. Uncertainty in Measurements and Significant figures are important concepts in physics. All measurements contain some uncertainty. The reporting of such data uses significant figures to inform the reader of the uncertainty in the measurement. When these values are used in calculations, it is vital that answers to such calculations are not misleading, and hence, rules, for addition, subtraction, multiplication, and division should be followed.

The measured data can be more easily analysed and interpreted if presented in a well structured table. The data in tabular form include a title, column headings showing the quantities measured and the unit used, and the values observed. Graphs are useful way of displaying data. Relationships between variables in an experiment can be shown by a line of best fit. The scatter of the points above and below the line is probably due to random errors. The slope and the intercepts of the line do have some physical significance whereas the intercept may also indicate the existence of a systematic error. Overall aim is to develop recording, interpreting and communicating skills needed for life long uses.

Major Concepts (19 periods)

- The scope of Physics
- SI base, supplementary and derived units
- Errors and uncertainties
- Use of significant figures
- Precision and accuracy
- Dimensionality

Conceptual linkage:

↓ This chapter is built on
Measurement Physics IX

Learning outcomes

Understanding

The students will:

- describe the scope of Physics in science, technology and society.
- state SI base units, derived units, and supplementary units for various measurements.
- express derived units as products or quotients of the base units.
- state the conventions for indicating units as set out in the SI units.
- explain why all measurements contain some uncertainty.
- distinguish between systematic errors (including zero errors) and random errors.
- identify that least count or resolution of a measuring instrument is the smallest increment measurable by it.
- differentiate between precision and accuracy.
- assess the uncertainty in a derived quantity by simple addition of actual, fractional or percentage uncertainties.
- quote answers with correct scientific notation, number of significant figures and units in all numerical and practical work.

- check the homogeneity of physical equations by using dimensionality and base units.
- derive formulae in simple cases using dimensions.

Investigation Skills/ Laboratory work

The students will:

- measure, using appropriate techniques, the length, mass, time, temperature and electrical quantities by making use of both analogue scales and digital displays particularly short time interval by ticker timer and by C.R.O.
- measure length and diameter of a solid cylinder and hence estimate its volume quoting proper number of significant figures.
- measure the diameters of a few ball bearings of different sizes and estimate their volumes. Mention the uncertainty in each result.
- analyze and evaluate the above experiment and suggest improvements.
- determine the radius of curvature of a convex lens and concave lens using a spherometer.
- explain why it is important to use an instrument of smallest resolution.
- explain the importance of increasing the number of readings in an experiment.
- demonstrate the information of general safety rules of the laboratory and proper use of safety equipments.

Science, Technology and Society Connections

The students will:

- present data in a well-structured tabular form for easy interpretation (e.g. ball bearings investigation).
- display data by drawing appropriate graphs for the above.
- interpret the information from linear or non linear graphs/curves by measuring slopes and intercepts in newspaper or magazines
- argue that all daily life measurements are uncertain to some extent.

Unit - 2 Vectors and Equilibrium

Overview: Equilibrium is a state of stability either due to a lack of change (Static equilibrium) or a balance between opposing forces (dynamic equilibrium). Thus an object moving without acceleration is in a dynamic equilibrium.

The static equilibrium represents a common situation in engineering practice, and the principles it involves are of special interest to civil engineers, architect and mechanical engineers.

Being able to determine the forces acting on an object in static equilibrium has many important applications such as the forces exerted by the cables of a suspension bridge must be known so that the cables can be designed to be strong enough to support the bridge. Similarly, cranes must be designed so that they do not topple over when lifting a heavy load.

Major Concepts (20 periods)

- Cartesian coordinate system
- Addition of vectors by head to tail rule
- Addition of vectors by perpendicular components
- Scalar product of two vectors
- Vectors product of two vectors
- Torque
- Equilibrium of forces
- Equilibrium of torques

Conceptual linkage:

↓ This chapter is built on
Turning Effect of Forces
Physics IX
Trigonometry Maths IX
Vector Algebra Maths XI

Learning outcomes

Understanding

The students will:

- describe the Cartesian coordinate system.
- determine the sum of vectors using head to tail rule.
- represent a vector into two perpendicular components.
- determine the sum of vectors using perpendicular components.
- describe scalar product of two vectors in term of angle between them.
- describe vector product of two vectors in term of angle between them.
- state the method to determine the direction of vector product of two vectors.
- define the torque as vector product $\mathbf{r} \times \mathbf{F}$.
- list applications of torque or moment due to a force.
- state first condition of equilibrium.
- state second condition of equilibrium.
- solve two dimensional problems involving forces (statics) using 1st and 2nd conditions of equilibrium.

➤ Investigation Skills/ Laboratory work

The students will:

- Determine the weight of a body by vector addition of forces using perpendicular components.
- Verify the two conditions of equilibrium using a suspended metre rod.

Science, Technology and Society Connections

The students will:

- identify the use of long handle spanner to turn a stubborn bolt.
- explain why the height of racing cars is kept low.
- explain why do buses and heavy trucks have large steering wheels.
- describe how cranes are able to lift very heavy loads without toppling.

Unit - 3 Forces and Motion

Overview: While distance, time and speed are fundamental to the understanding of kinematics and dynamics, very few people consider transportation in terms of energy, force or the momentum associated with the vehicle, even at low or moderate speeds. Major damage can be done to other vehicles' and to the human body in collisions, even at low speeds. This is because during a collision some or all of the vehicle's kinetic energy is dissipated through the vehicle and the object with which it collides. Further, the materials from which vehicles are constructed do not deform or bend as easily as the human body. Technological advances and systematic study of vehicle crashes have increased understanding of the interactions involved, the potential resultant damage and possible ways of reducing the effects of collisions. There are many safety devices now installed in or on vehicles, including seat belts and air bags. Modern road design takes into account ways in which vehicles can be forced to reduce their speed.

Another important concept is the projectile motion. The path of projectile is the resultant of simultaneous effect on the horizontal and vertical components of its velocity but these components act independently. The vertical component determines the time of flight and horizontal component determines the range. The effect of air resistance on the motion is treated qualitatively. These key ideas are applied to projectiles in sport (e.g. a shot-put).

This unit increases students' understanding of the nature and practice of physics and the implications of physics for society and the environment.

Major Concepts (30 periods)

- Displacement
- Average velocity and instantaneous velocity
- Average acceleration and instantaneous acceleration
- Review of equations of uniformly accelerated motion
- Newton's laws of motion
- Momentum and Impulse
- Law of conservation of momentum
- Elastic collisions in one dimension
- Momentum and explosive forces
- Projectile motion
- Rocket motion

Conceptual linkage:

↓ This chapter is built on
Kinematics & Dynamics
Physics IX

Learning Outcomes

Understanding

The students will:

- describe vector nature of displacement.
- describe average and instantaneous velocities of objects.
- compare average and instantaneous speeds with average and instantaneous velocities.
- interpret displacement-time and velocity-time graphs of objects moving along the same straight line.

- determine the instantaneous velocity of an object moving along the same straight line by measuring the slope of displacement-time graph.
- define average acceleration (as rate of change of velocity $a_{av} = \Delta v / \Delta t$) and instantaneous acceleration (as the limiting value of average acceleration when time interval Δt approaches zero).
- distinguish between positive and negative acceleration, uniform and variable acceleration.
- determine the instantaneous acceleration of an object measuring the slope of velocity-time graph.
- manipulate equation of uniformly accelerated motion to solve problems.
- explain that projectile motion is two dimensional motion in a vertical plane.
- communicate the ideas of a projectile in the absence of air resistance that.
 - (i) Horizontal component (V_H) of velocity is constant.
 - (ii) Acceleration is in the vertical direction and is the same as that of a vertically free falling object.
 - (iii) The horizontal motion and vertical motion are independent of each other.
- evaluate using equations of uniformly accelerated motion that for a given initial velocity of frictionless projectile.
 1. How higher does it go?
 2. How far would it go along the level land?
 3. Where would it be after a given time?
 4. How long will it remain in air?
- determine for a projectile launched from ground height.
 1. launch angle that results in the maximum range.
 2. relation between the launch angles that result in the same range.
- describe how air resistance affects both the horizontal component and vertical component of velocity and hence the range of the projectile.
- apply Newton's laws to explain the motion of objects in a variety of context.
- define mass (as the property of a body which resists change in motion).
- describe and use of the concept of weight as the effect of a gravitational field on a mass.
- describe the Newton's second law of motion as rate of change of momentum.
- co-relate Newton's third law of motion and conservation of momentum.
- show awareness that Newton's Laws are not exact but provide a good approximation, unless an object is moving close to the speed of light or is small enough that quantum effects become significant.
- define Impulse (as a product of impulsive force and time).
- describe the effect of an impulsive force on the momentum of an object, and the effect of lengthening the time, stopping, or rebounding from the collision.
- describe that while momentum of a system is always conserved in interaction between bodies some change in K.E. usually takes place.
- solve different problems of elastic and inelastic collisions between two bodies in one dimension by using law of conservation of momentum.
- describe that momentum is conserved in all situations.
- identify that for a perfectly elastic collision, the relative speed of approach is equal to the relative speed of separation.
- differentiate between explosion and collision (objects move apart instead of coming nearer).

➤ Investigation Skills/ Laboratory work

The students will:

- analyse and interpret patterns of motion of objects using
 - (i) Displacement-time graph
 - (ii) Velocity-time graph
 - (iii) Acceleration-time graph
- measure the free fall time of a ball using a ticker-timer and hence calculate the value of “g”. Evaluate your result and identify the sources of error and suggest improvements.
- investigate the value of “g” by free fall method
- investigate momentum conservation by colliding trolleys and ticker-timer for elastic and inelastic collisions
- investigate the downward force, along an inclined plane, acting on a roller due to gravity and study its relationship with the angle of inclination by plotting graph between force and $\sin \theta$

Science, Technology and Society Connections

The students will:

- Outline the forces involved in causing a change in the velocity of a vehicle when
 - coasting with no pressure on the accelerator.
 - pressing on the accelerator.
 - pressing on the brakes.
 - passing over an icy patch on the road.
 - climbing and descending hills.
- investigate and explain the effect of the launch height of a projectiles (e.g. a shot put launched from a shoulder height) on a maximum range and the affect of launch angle for a given height.
- describe to what extent the air resistance affects various projectiles in sports
- evaluate the effectiveness of some safety features of motor vehicles in connection with the changing momentum such as safety helmet, seat belt, head rest of the car seat.
- describe the conservation of momentum for (i) car crashes (ii) ball & bat.
- assess the reasons for the introduction of low speed zones in built-up areas and the addition of air bags and crumple zones to vehicles with respect to the concepts of impulse and momentum.
- explain in terms of law of conservation of momentum, the motion under thrust of a rocket in a straight line considering short thrusts during which the mass remains constant
- describe the nature of the rocket thrusts necessary to cause a space vehicle to change direction along a circular arc in a region of space where gravity is negligible

Unit – 4 Work and Energy

Overview: The concept of energy is closely associated with that of work. When work is done by one system on another, energy is transferred between the two systems. There are many forms of energy and all energy forms can be classified as potential or kinetic energy. Potential energy is stored energy and includes chemical, gravitational, electrostatic, elastic, and nuclear. Kinetic energy is the energy of motion. We daily observe many energy transformations from one form to another. Some forms, such as electrical and chemical, are more easily transferred than others, such as heat. Ultimately, all energy transfers result in heating of the environment and energy does not remain available for doing useful work. If it seems, in an energy transfer, that some energy has disappeared, the lost energy is often converted into heat. This appears to be the fate of all available energies and is one reason why new sources of useful energy have to be developed. The present conventional energy sources are inadequate to cope up with the ever increasing energy demand. New and innovate energy resources have to be explored. Wise use of available energy without sacrificing the essential comforts of life is also one energy source to which we can all contribute by developing the habit of saving unnecessary wastage of energy.

Major Concepts (17 periods)

- Work done by a constant force
- Work as scalar product of force and displacement
- Work against gravity
- Work done by variable force
- Gravitational Potential at a point
- Escape velocity
- Power as scalar product of force and velocity
- Work energy principle in resistive medium
- Sources and uses of energy
 - (i) Conventional sources of energy
 - (ii) Non conventional sources of energy

Conceptual linkage:

↓ This chapter is built on
Work and energy
Physics IX
Gravitation Physics IX

Learning Outcomes:

Understanding

The students will:

- describe the concept of work in terms of the product of force F and displacement d in the direction of force (Work as scalar product of F and d).
- distinguish between positive, negative and zero work with suitable examples.
- describe that work can be calculated from the area under the force-displacement graph.
- explain gravitational field as an example of field of force and define gravitational field strength as force per unit mass at a given point.
- prove that gravitational field is a conservative field.

- compute and show that the work done by gravity as a mass 'm' is moved from one given point to another does not depend on the path followed.
- describe that the gravitational PE is measured from a reference level and can be positive or negative, to denote the orientation from the reference level.
- define potential at a point as work done in bringing unit mass from infinity to that point.
- explain the concept of escape velocity in term of gravitational constant G, mass m and radius of planet r.
- differentiate conservative and non conservative forces giving examples of each.
- express power as scalar product of force and velocity.
- explain that work done against friction is dissipated as heat in the environment.
- state the implications of energy losses in practical devices and the concept of efficiency.
- utilize work – energy theorem in a resistive medium to solve problems.
- discuss and make a list of limitations of some conventional sources of energy.
- describe the potentials of some nonconventional sources of energy.

➤ Investigation Skills/ Laboratory work

The students will:

- investigate, at construction sites by comparing a labourer and an electric motor for carrying the bricks to the top of the building. Identify the economy involved.
- investigate that if a ping pong ball is dropped from rest onto a hard plane surface, it usually returns to 75% of its original height after bouncing. What percentage of the energy of the ping pong ball is lost on each bounce? What happens to that energy?
- design an investigation to determine how the efficiency of an electric motor varies with load.

Science, Technology and Society Connections

The students will:

- identify, by estimating the cost, benefits of application of scientific principles related, to work and energy in lifting objects by a crane.
- explain why a car going up a hill requires lower top speed than a car going on the flat.
- identify energy conversions.
 - (i) moving car engine
 - (ii) thermal power station
 - (iii) Hydroelectric power station
- investigate and explain how global climate is determined by energy transfer from the Sun and is influenced by a dynamic process (e.g. cloud formation and the earth's rotation) and static conditions (e.g. the position of mountain ranges and oceans)
- explain how trash can be utilized for producing energy (bio-gas).

Unit - 5 Rotational and Circular Motion

Overview: Rotational motion is common observation all around us from molecules to galaxies. The earth rotates about its axis. Wheels, gears, propellers, motors, drive shaft of car, a CD in its player, all rotates. Many of the features of rotational motion can be derived from analogy with translational motion, such as the equations of motion. Circular motion with special emphasis on the banking of roads have been introduced. The relations between such quantities as torque, moment of inertia and angular momentum are to be explained.

Newton's law of universal gravitation is used to extend the study of uniform circular motion to the centripetal acceleration caused by the gravitational force on a satellite. These key ideas are applied to weather and communication satellites. Rapid advances in technologies over the past fifty years have allowed the exploration of not only the Moon, but the Solar System and, to an increasing extent, the Universe. Space exploration is becoming more viable. Information from research undertaken in space programs has impacted on society through the development of devices such as personal computers, advanced medical equipment and communication satellites, and has enabled the accurate mapping of natural resources. Space research and exploration increases our understanding of the Earth's own environment, the Solar System and the Universe. This unit increases students' understanding of the history, nature and practice of physics and the implications of physics for society and the environment.

Major Concepts (21 periods)

- Kinematics of angular motion
- Centripetal force and centripetal acceleration
- Orbital velocity
- Artificial satellites
- Artificial gravity
- Moment of inertia
- Angular momentum

Conceptual linkage:

↓ This chapter is built on
Dynamics Physics IX
Turning Effect of Forces
Physics IX

Learning Outcomes

Understanding

The students will:

- define angular displacement, angular velocity and angular acceleration and express angular displacement in radians.
- solve problems by using $S = r\theta$ and $v = r\omega$.
- state and use of equations of angular motion to solve problems involving rotational motions.
- describe qualitatively motion in a curved path due to a perpendicular force.
- derive and use centripetal acceleration $a = r\omega^2$, $a = v^2/r$.

- solve problems using centripetal force $F = mr\omega^2$, $F = mv^2 / r$.
- describe situations in which the centripetal acceleration is caused by a tension force, a frictional force, a gravitational force, or a normal force.
- explain when a vehicle travels round a banked curve at the specified speed for the banking angle, the horizontal component of the normal force on the vehicle causes the centripetal acceleration.
- describe the equation $\tan\theta = v^2/rg$, relating banking angle θ to the speed v of the vehicle and the radius of curvature r .
- explain that satellites can be put into orbits round the earth because of the gravitational force between the earth and the satellite.
- explain that the objects in orbiting satellites appear to be weightless.
- describe how artificial gravity is created to counter balance weightless.
- define the term orbital velocity and derive relationship between orbital velocity, the gravitational constant, mass and the radius of the orbit.
- analyze that satellites can be used to send information between places on the earth which are far apart, to monitor conditions on earth, including the weather, and to observe the universe without the atmosphere getting in the way.
- describe that communication satellites are usually put into orbit high above the equator and that they orbit the earth once a day so that they appear stationary when viewed from earth.
- define moment of inertia of a body and angular momentum.
- derive a relation between torque, moment of inertia and angular acceleration.
- explain conservation of angular momentum as a universal law and describe examples of conservation of angular momentum.
- use the formulae of moment of inertia of various bodies for solving problems.

➤ Investigation Skills/ Laboratory work

The students will:

- demonstrate the conservation of angular momentum by spinning stool and dumbles (weights).
- demonstrate the action of a centrifuge e.g. washing machine dryer.
- determine the moment of inertia of a fly wheel.

Science, Technology and Society Connections

The students will:

- assess the suitability of the recommended speed limit for the given data on the banking angle and radius of curvature of some roads.
- describe the experience of roller coaster rides in the amusement parks.
- describe the principles and benefits of weather forecasting and communication satellites.
- evaluate the accuracy of the information presented in a newspaper article on satellite.
- write a report on an information search on the topic of 'space station'

Unit # 6 Fluid Dynamics

Overview: The study of fluids in motion is relatively complex, but analysis can be simplified by making a few assumptions such as fluid under consideration is non-viscous, incompressible and its motion is steady. The analysis is further simplified by the use of two important conservation principles, the conservation of mass and conservation of energy. The law of conservation of mass gives us the equation of continuity while the law of conservation of energy is the basis of Bernoulli's equation. The equation of continuity and the Bernoulli's equation alongwith their numerous applications in everyday life, including sports, transportation, technology and medical physics have been discussed in this unit.

Major Concepts (18 periods)

- Streamline and Turbulent flow
- Equation of continuity
- Bernoulli's equation
- Applications of Bernoulli's equation
- Viscous fluids
- Fluid Friction
- Terminal velocity

Conceptual linkage:

↓ This chapter is built on
Work & Energy Physics IX
Dynamics Physics IX
Properties of Matter Physics IX

Learning Outcomes

Understanding

The students will:

- define the terms: steady (streamline or laminar) flow, incompressible flow and non viscous flow as applied to the motion of an ideal fluid.
- explain that at a sufficiently high velocity, the flow of viscous fluid undergoes a transition from laminar to turbulence conditions.
- describe that the majority of practical examples of fluid flow and resistance to motion in fluids involve turbulent rather than laminar conditions.
- describe equation of continuity $Av = \text{Constant}$, for the flow of an ideal and incompressible fluid and solve problems using it.
- identify that the equation of continuity is a form of the principle of conservation of mass.
- describe that the pressure difference can arise from different rates of flow of a fluid (Bernoulli effect).
- derive Bernoulli equation in the form $P + \frac{1}{2} \rho v^2 + \rho gh = \text{constant}$ for the case of horizontal tube of flow.
- interpret and apply Bernoulli Effect in the: filter pump, Venturi meter, in, atomizers, flow of air over an aerofoil and in blood physics.
- describe that real fluids are viscous fluids.
- describe that viscous forces in a fluid cause a retarding force on an object moving through it.

- explain how the magnitude of the viscous force in fluid flow depends on the shape and velocity of the object.
- apply dimensional analysis to confirm the form of the equation $F = A\eta rv$ where 'A' is a dimensionless constant (Stokes' Law) for the drag force under laminar conditions in a viscous fluid.
- apply Stokes' law to derive an expression for terminal velocity of spherical body falling through a viscous fluid.

➤ Investigation Skills/ Laboratory work

The students will:

- investigate the effect of moving air on pressure by demonstrating with Venturi meter.
- investigate the fall of spherical steel balls through a viscous medium and determine
 - (i) terminal velocity
 - (ii) coefficient of viscosity of the fluid
- investigate the viscosity of different liquids by measuring the terminal velocity.
- describe of systolic pressure and diastolic pressure and use sphygmomanometer to measure blood pressure.

Science, Technology and Society Connections

The students will:

- show that a table tennis ball can be made suspended in the stream of air coming from the nozzle of hair dryer.
- explain the streamlined designing of racing cars and boats.
- explain that the streamlined bodies of dolphins assist their movement in water.
- describe that when water falls from a tap, its speed increases and so its cross sectional area decreases as mandated by the continuity equation.
- describe that a stream of air passing over a tubes dipped in liquid will cause the liquid to rise in the tube. This effect is used in perfume bottles and paint sprayers.
- explain why a chimney works best when it is tall and exposed to air currents which reduces the pressure at the top and forces the upward flow of smoke.
- state qualitative explanations in terms of turbulence and Bernoulli Effect for the swing of spinning cricket ball and the lift of a spinning golf ball.
- describe that a filter pump has constriction in the centre, so that a jet of water from the tap flows faster here.
- explain that the carburettor of a car engine uses a Venturi duct to feed the correct mix of air and petrol to the cylinders.

Unit – 7 Oscillations

Overview: Vibrational motion is as important as translational and rotational motions. There are many phenomena in nature whose explanation requires the understanding of the concepts of vibrations and waves. Although many large structures, such as skyscrapers and bridges appear to be rigid, actually vibrate. The architects and the engineers who design and build them take this fact into account.

Resonance is a striking phenomenon associated with vibratory motion which enables maximum energy transfer. Tuning of radio and TV programmes, heating and cooking of food efficiently and evenly by microwaves ovens are wonderful applications of resonance. There are also situations where resonance is avoided such as aeroplane wings or helicopter rotor and suspension bridges etc. Damped oscillations are basis of shock absorbers of a car providing damping force to prevent excessive oscillation on rough roads.

Major Concepts (23 periods)

- Simple Harmonic Motion (SHM)
- Circular motion and SHM
- Practical SHM system
(mass spring and simple pendulum)
- Energy conservation in SHM
- Free and forced oscillations
- Resonance
- Damped oscillations

Conceptual linkage:

↓ This chapter is built on
Circular Motion Physics XI
Oscillation & Waves Physics XI

Learning Outcomes Understanding

The students will:

- describe simple examples of free oscillations.
- describe necessary conditions for execution of simple harmonic motions.
- describe that when an object moves in a circle, the motion of its projection on the diameter of the circles is SHM.
- define the terms amplitude, period, frequency, angular frequency and phase difference and express the period in terms of both frequency and angular frequency.
- identify and use the equation; $a = -\omega^2 x$ as the defining equation of SHM.
- prove that the motion of mass attached to a spring is SHM.
- describe the interchanging between kinetic energy and potential energy during SHM.
- analyze the motion of a simple pendulum is SHM and calculate its time period.
- describe practical examples of free and forced oscillations (resonance).
- describe graphically how the amplitude of a forced oscillation changes with frequency near to the natural frequency of the system.

- describe practical examples of damped oscillations with particular reference to the effects of the degree of damping and the importance of critical damping in cases such as a car suspension system.
- describe qualitatively the factors which determine the frequency response and sharpness of the resonance.

➤ Investigation Skills/ Laboratory work

The students will:

- verify that the time period of the simple pendulum is directly proportional to the square root of its length and hence find the value of g from the graph.
- determine the acceleration due to gravity by oscillating mass-spring system.
- determine the value of g by vibrating a metal lamina suspending from different points.

Science, Technology and Society Connections

The students will:

- explain the importance of critical damping in a car suspension system.
- identify that there are some circumstances in which resonance is useful such as tuning a radio, microwave oven and other circumstances in which resonance should be avoided such as aeroplane's wing or helicopter rotor, suspension bridge etc.

Unit – 8 Waves

Overview: Sound and light transfer energy from one location to another as waves. Characteristics of waves include wavelength, amplitude, and frequency. Waves can combine with one another, bend around corners, reflect off surfaces, be absorbed by materials they enter, and change direction when entering a new material. All these effects vary with wavelength. Observable waves include mechanical and electromagnetic waves. Mechanical waves transport energy through a medium. Electromagnetic radiation is differentiated by wavelength or frequency, and includes radiowaves, microwaves, infrared, visible light, ultraviolet radiation, x-rays, and gamma rays. These wavelengths vary from radiowaves (the longest) to gamma rays (the shortest). In empty space all electromagnetic waves move at the same speed, the “speed of light.” The apparent change in frequency due to relative motion of source and observer known as Doppler effect has many applications such as operating principle of a radar, radar speed trap for vehicles on motorways and in astronomical studies.

Major Concepts (27 periods)

- Periodic waves
- Progressive waves
- Transverse and longitudinal waves
- Speed of sound in air
- Newton’s formula and Laplace correction
- Superposition of waves
- Stationary waves
- Modes of vibration of strings
- Fundamental mode and harmonics
- Vibrating air columns and organ pipes
- Doppler effect and its applications
- Generation, detection and use of ultrasonic

Conceptual linkage:

↓ This chapter is built on
Sound Science VII & VIII
Oscillation & Waves Physics IX

Learning Outcomes

Understanding

The students will:

- describe what is meant by wave motion as illustrated by vibrations in ropes, springs and ripple tank.
- demonstrate that mechanical waves require a medium for their propagation while electromagnetic waves do not.
- define and apply the following terms to the wave model; medium, displacement, amplitude, period, compression, rarefaction, crest, trough, wavelength, velocity.
- solve problems using the equation: $v = f\lambda$.
- describe that energy is transferred due to a progressive wave.
- identify that sound waves are vibrations of particles in a medium.
- compare transverse and longitudinal waves.

- explain that speed of sound depends on the properties of medium in which it propagates and describe Newton's formula of speed of waves.
- describe the Laplace correction in Newton's formula for speed of sound in air.
- Identify the factors on which speed of sound in air depends.
- describe the principle of superposition of two waves from coherent sources.
- describe the phenomenon of interference of sound waves.
- describe the phenomenon of formation of beats due to interference of non coherent sources.
- explain the formation of stationary waves using graphical method
- define the terms, node and antinodes.
- describe modes of vibration of strings.
- describe formation of stationary waves in vibrating air columns.
- explain the observed change in frequency of a mechanical wave coming from a moving object as it approaches and moves away (i.e. Doppler effect).
- explain that Doppler effect is also applicable to e.m. waves.
- explain the principle of the generation and detection of ultrasonic waves using piezo-electric transducers.
- explain the main principles behind the use of ultrasound to obtain diagnostic information about internal structures.

➤ Investigation Skills/ Laboratory work

The students will:

- investigate, sketch and interpret the behaviour of wave fronts as they reflect, refract, and diffract by observing (i) Pond ripples / ocean waves / harbour waves / amusement park waves pools.
- determine frequency of A.C. by Melde's apparatus/electric sonometer.
- investigate the laws of vibration of stretched strings by sonometer or electromagnetic method.
- determine the wavelength of sound in air using stationary waves and to calculate the speed of sound using resonance tube.
- study the interference of ultrasonic waves in a Young's experiment arrangement and determine the wavelength of ultrasonic waves.

Science, Technology and Society Connections

The students will:

- explain the tuning of musical instruments by beats.
- explain the applications of Doppler effect such as radar, sonar, astronomy, satellite and radar speed traps.
- outline some cardiac problems that can be detected through the use of the Doppler's effect.
- describe the working of ultrasonic cleaners.

Unit – 9 Physical Optics

Overview: Interference and diffraction are two phenomena most easily understood in terms of the propagation of light as a wave. Interference of light occurs when two or more light sources are superimposed. Diffraction of light occurs when part of its wave-front is obstructed (e.g. by a narrow slit). Diffraction is treated qualitatively as a precursor to a more extended quantitative treatment of the interference of light from two slits. This is extended to the transmission diffraction grating. Polarization which establishes transverse nature of light waves along with its applications have also been discussed in this unit.

Major Concepts (25 periods)

- Nature of light
- Wave front
- Huygen's principle
- Interference
 - Young's double slit experiment
 - Michleson's Interferometer
- Diffraction
- Polarization

Conceptual linkage:

↓ This chapter is built on
Properties of Waves Physics IX

Learning outcomes

Understanding

The students will:

- describe light waves as a part of electromagnetic waves spectrum.
- describe the concept of wave front.
- state Huygen's principle and use it to construct wave front after a time interval.
- state the necessary conditions to observe interference of light.
- describe Young's double slit experiment and the evidence it provides to support the wave theory of light.
- explain colour pattern due to interference in thin films.
- describe the parts and working of Michleson Interferometer and its uses.
- explain diffraction and identify that interference occurs between waves that have been diffracted.
- describe that diffraction of light is evidence that light behaves like waves.
- describe and explain diffraction at a narrow slit.
- describe the use of a diffraction grating to determine the wavelength of light and carry out calculations using $d\sin\theta=n\lambda$.
- describe the phenomena of diffraction of X-rays through crystals.
- explain polarization as a phenomenon associated with transverse waves.
- identify and express that polarization is produced by a Polaroid.
- explain the effect of rotation of Polaroid on Polarization.
- explain how plane polarized light is produced and detected.

➤ Investigation Skills/ Laboratory work

The students will:

- investigate that light can be diffracted but needs a very small slit because the wavelength of light is small.
- demonstrate diffraction including the diffraction of water waves in a ripple tank with both a wide gap and a narrow gap.
- measure the slit separation/ grating element 'd' of a diffraction grating by using the known wavelength of laser light.
- demonstrate the interference, diffraction and polarization of e.m. waves by Using microwave apparatus.
- determine the wavelength of light by using a diffraction grating and spectrometer.
- measure the diameter of a wire or hair using laser.
- determine the pick count of a nylon mesh by using a diffraction grating and laser.
- demonstrate polarization of light waves using two Polaroid glasses and LDR and hence, verify Malus' law.

Science, Technology and Society Connections

The students will:

- describe the diffraction of X-rays to study the crystalline structures of various materials.
- explain the use of Polaroid in the sky photography, concentration of sugar and tartaric acid in solutions, stress analysis of materials.

Unit – 10 Thermodynamics

Overview: Thermodynamics is the science that deals with the transformation of heat into other forms of energy. An example of such transformation is the process converting heat into mechanical work. Thermodynamics thus plays central role in technology, since almost all the raw energy available for our use is liberated in the form of heat. The total energy of the universe is although constant; however, the total amount of energy available for useful transformation is almost always decreasing. Transformation of energy usually produces heat that spreads to cooler places by radiation, convection, or conduction. Everything tends to become less organized and less orderly over time. The second law of thermodynamics provides us the key for both understanding our environmental crisis, and for understanding how we must deal with this crisis. According to this law, any increase in the order in a system will produce an even greater increase in disorder in the environment. An individual impact may not have a major consequences but an impact of large number of all individual disorder producing activities can affect the overall life support system.

The imperative from thermodynamics is that whenever you do anything, be sure to take into account its present and possible future impact on your environment. This is an ecological imperative that we must consider now if we are to prevent a drastic degradation of life on our beautiful but the fragile earth.

This unit increases students' understanding of the applications and uses of physics and the implications of physics for society and the environment.

Major Concepts (22 periods)

- Thermal equilibrium
- Heat and work
- Internal energy
- First law of thermodynamics
- Molar specific heats of a gas
- Heat engine
- Second law of thermodynamics
- Carnot's cycle
- Refrigerator
- Entropy

Conceptual linkage:

↓ This chapter is built on
Heat Physics IX
Thermo Chemistry XI

Learning Outcomes

Understanding

The students will:

- describe that thermal energy is transferred from a region of higher temperature to a region of lower temperature.
- describe that regions of equal temperatures are in thermal equilibrium .
- describe that heat flow and work are two forms of energy transfer between systems and calculate heat being transferred.
- define thermodynamics and various terms associated with it.

- relate a rise in temperature of a body to an increase in its internal energy.
- describe the mechanical equivalent of heat concept, as it was historically developed, and solve problems involving work being done and temperature change.
- explain that internal energy is determined by the state of the system and that it can be expressed as the sum of the random distribution of kinetic and potential energies associated with the molecules of the system.
- calculate work done by a thermodynamic system during a volume change.
- describe the first law of thermodynamics expressed in terms of the change in internal energy, the heating of the system and work done on the system.
- explain that first law of thermodynamics expresses the conservation of energy.
- define the terms, specific heat and molar specific heats of a gas.
- apply first law of thermodynamics to derive $C_p - C_v = R$.
- state the working principle of heat engine.
- describe the concept of reversible and irreversible processes.
- state and explain second law of thermodynamics.
- explain the working principle of Carnot's engine
- explain that the efficiency of a Carnot engine is independent of the nature of the working substance and depends on the temperatures of hot and cold reservoirs.
- describe that refrigerator is a heat engine operating in reverse as that of an ideal heat engine.
- derive an expression for the coefficient of performance of a refrigerator.
- describe that change in entropy is positive when heat is added and negative when heat is removed from the system.
- explain that increase in temperature increases the disorder of the system.
- explain that increase in entropy means degradation of energy.
- explain that energy is degraded during all natural processes.
- identify that system tend to become less orderly over time.

➤ Investigation Skills/ Laboratory work

The students will:

- determine the mechanical equivalent of heat by electric method.
- determine the specific heat of solid by electrical method.

Science, Technology and Society Connections

The students will:

- describe the working of petrol engine and diesel engine.
- evaluate environmental crisis as an entropy crisis.

Unit – 11 Electrostatics

Overview: Two fundamental processes of electrostatics are introduced: Coulomb's law for force between stationary charges and the principle of superposition for electric field configurations. The electric field at a point in space is defined and used, with Coulomb's law, to derive an expression for the electric field at a distance from a point charge. In this topic the charges are assumed to be in a vacuum (or, for practical purposes, air). The concept of work done by an electric field on a charged particle is introduced. For practical purposes, the concept of electric field is translated into concepts of electric potential and electrical potential energy. The potential difference between a pair of parallel plates is used to determine the electric field between the plates.

The principle of superposition explains the fact that a near-uniform electric field can be produced by two charged parallel conducting plates. The absence of an electric field in hollow conductors is discussed. The presence of strong electric fields in the vicinity of sharp points on charged conductors is identified and applied to corona discharges in relation to photocopiers and laser printers.

Another quantity being discussed that plays an important role in electrical circuits is capacitance and its dependence on the dielectrics.

Major Concepts (21 periods)

- Force between charges in different media
- Electric field
- Electric field of various charge configurations
- Electric field due to a dipole
- Electric flux
- Gauss's law and its applications
- Electric potential
- Capacitors
- Energy stored in a capacitor

Conceptual linkage:

↓ This chapter is built on
Electrostatics Physics X

Learning Outcomes Understanding

The students will:

- state Coulomb's law and explain that force between two point charges is reduced in a medium other than free space using Coulomb's law.
- derive the expression $E = 1/4\pi\epsilon_0 q/r^2$ for the magnitude of the electric field at a distance 'r' from a point charge 'q'.
- describe the concept of an electric field as an example of a field of force.
- define electric field strength as force per unit positive charge .
- solve problems and analyse information using $E = F/q$.
- solve problems involving the use of the expression .
- $E = 1/4\pi\epsilon_0 q/r^2$

- calculate the magnitude and direction of the electric field at a point due to two charges with the same or opposite signs.
- sketch the electric field lines for two point charges of equal magnitude with same or opposite signs.
- describe the concept of electric dipole.
- define and explain electric flux.
- describe electric flux through a surface enclosing a charge.
- state and explain Gauss's law.
- describe and draw the electric field due to an infinite size conducting plate of positive or negative charge.
- sketch the electric field produced by a hollow spherical charged conductor.
- sketch the electric field between and near the edges of two infinite size oppositely charged parallel plates.
- define electric potential at a point in terms of the work done in bringing unit positive charge from infinity to that point.
- define the unit of potential.
- solve problems by using the expression $V = W/q$.
- describe that the electric field at a point is given by the negative of potential gradient at that point.
- solve problems by using the expression $E = V/d$.
- derive an expression for electric potential at a point due to a point charge.
- calculate the potential in the field of a point charge using the equation $V = 1/4\pi\epsilon_0 q/r$.
- define and become familiar with the use of electron volt.
- define capacitance and the farad and solve problems by using $C=Q/V$.
- describe the functions of capacitors in simple circuits.
- solve problems using formula for capacitors in series and in parallel.
- explain polarization of dielectric of a capacitor.
- demonstrate charging and discharging of a capacitor through a resistance.
- prove that energy stored in a capacitor is $W=1/2QV$ and hence $W=1/2CV^2$.

➤ Investigation Skills/ Laboratory work

The students will:

- draw graphs of charging and discharging of a capacitor through a resistor.

Science, Technology and Society Connections

The students will:

- describe the principle of inkjet printers and Photostat copier as an application of electrostatic phenomenon.
- describe the applications of Gauss's law to find the electric force due to various charge configurations
- list the use of capacitors in various household appliances such as in flash gun of camera, refrigerator, electric fan, rectification circuit etc.

Unit 12 Current Electricity

Overview: Current electricity is the study of charges in motion. Simple electrical circuits can be solved by applying Ohm's law. For other circuits, Kirchhoff rules are applied.

We all enjoy the comforts and benefits of using electricity. Electricity has characteristics that have made it uniquely appropriate for powering an emerging technological society. There are many energy sources that can be readily converted into electricity. Most power plants burn fossil fuel, or use the energy of falling water to generate electricity on a large scale. Electricity is also relatively easy to distribute. Electricity authorities use high-voltage transmission lines and transformers to distribute electricity to homes and industries in a town. Voltages can be as high as 5×10^5 volts from power stations but by the time this reaches homes, the electricity has been transformed to 240 volts. While it is relatively economical to generate electric power at a steady rate, there are both financial and environmental issues that should be considered when assessing the long-term impact of supplying commercial and household power.

Major Concepts (36 periods)

- Steady current
- Electric potential difference
- Resistivity and its dependence upon temperature
- Internal resistance
- power dissipation in resistance
- Thermoelectricity
- Kirchhoff's Laws
- The potential divider
- Balanced potentials (Wheatstone bridge and potentiometer)

Conceptual linkage:

↓ This chapter is built on
Current Electricity Physics X

Learning outcomes

Understanding

The students will:

- describe the concept of steady current.
- state Ohm's law.
- define resistivity and explain its dependence upon temperature.
- define conductance and conductivity of conductor.
- state the characteristics of a thermistor and its use to measure low temperatures.
- distinguish between e.m.f and p.d. using the energy considerations.
- explain the internal resistance of sources and its consequences for external circuits.
- describe some sources of e.m.f.
- describe the conditions for maximum power transfer.
- describe thermocouple and its function.
- explain variation of thermoelectric e.m.f. with temperature.

- apply Kirchhoff's first law as conservation of charge to solve problem.
- apply Kirchhoff's second law as conservation of energy to solve problem.
- describe the working of rheostat in the potential divider circuit.
- describe what is a Wheatstone bridge and how it is used to find unknown resistance.
- describe the function of potentiometer to measure and compare potentials without drawing any current from the circuit.

Investigation Skills/ Laboratory work

The students will:

- indicate the value of resistance by reading colour code on it.
- determine resistance of wire by slide wire bridge.
- determine resistance of voltmeter by drawing graph between R and I/V.
- determine resistance of voltmeter by discharging a capacitor through it.
- analyze the variation of resistance of thermistor with temperature.
- determine internal resistance of a cell using potentiometer.
- determine e.m.f of a cell using potentiometer.
- determine the e.m.f. and internal resistance of a cell by plotting V against I graph.
- investigate the relationship between current passing through a tungsten filament lamp and the potential applied across it.

Science, Technology and Society Connections

The students will:

- describe the use of electrocardiograph (E.C.G.), electroencephalograph (E.E.G) instruments to study heart and brain disorders.
- Explain that the inspectors can easily check the reliability of a concrete bridge with carbon fibres as the fibre conduct electricity.
- identify the function of thermistor in fire alarms and thermostats that control temperature.
- Identify the use of platinum resistance thermometer as standard thermometer for temperatures between -185°C to 630°C .
- identify the use of thermoelectric thermometer as a standard thermometer to measure temperatures between 630°C and 1063°C .

Unit – 13 Electromagnetism

Overview: Whenever a charge is moving it produces a magnetic field. The magnetic field may exert force on other moving charges, and hence on current-carrying conductors. The interaction between magnetic fields and electric currents is described and used to define the strength of the magnetic field in terms of the force on current-carrying conductors. The theory is then applied to the moving-coil galvanometer. The analytical relation between current and the magnetic field it produces is stated by Ampere's law which is used to find the MF of a solenoid.

The interaction of current-carrying conductors and magnetic fields is extended to the interaction of moving charged particles and uniform magnetic fields. The magnetic force on a moving charged particle is velocity-dependent, whereas electric forces are not. The circular path of charged particles moving at right angles to a uniform magnetic field is discussed.

Major Concepts (18 periods)

- Magnetic field of current –carrying conductor
- Magnetic force on a current-carrying conductor
- Magnetic flux density
- Ampere's law and its application in solenoid
- Force on a moving charged particle in a magnetic field
- e/m of an electron
- Torque on a current carrying coil in a magnetic field
- Electro-mechanical instruments

Conceptual linkage:

↓ This chapter is built on Electromagnetism Physics X

Learning Outcomes

Understanding

The students will:

- explain that magnetic field is an example of a field of force produced either by current-carrying conductors or by permanent magnets.
- describe magnetic effect of current.
- describe and sketch field lines pattern due to a long straight wire.
- explain that a force might act on a current-carrying conductor placed in a magnetic field.
- Investigate the factors affecting the force on a current carrying conductor in a magnetic field.
- solve problems involving the use of $F = BIL \sin \theta$.
- define magnetic flux density and its units.
- describe the concept of magnetic flux (Φ) as scalar product of magnetic field (B) and area (A) using the relation $\Phi = B \cdot A = BA \cos \theta$.
- state Ampere's law.
- apply Ampere's law to find magnetic flux density around a wire and inside a solenoid.

- describe quantitatively the path followed by a charged particle shot into a magnetic field in a direction perpendicular to the field.
- explain that a force may act on a charged particle in a uniform magnetic field.
- describe a method to measure the e/m of an electron by applying magnetic field and electric field on a beam of electrons.
- predict the turning effect on a current carrying coil in a magnetic field and use this principle to understand the construction and working of a galvanometer.
- explain how a given galvanometer can be converted into a voltmeter or ammeter of a specified range.
- describe the use of avometer / multimeter (analogue and digital).

Investigation Skills/ Laboratory work

The students will:

- construct a simple electromagnet and investigate the factors which influence the strength of an electromagnet.
- convert a galvanometer into voltmeter of range zero to 3 V.
- interpret and illustrate on the basis of experimental data, the magnetic field produced by a current flowing in a coil is stronger than a straight conductor.
- examine the motion of electrons in an electric field using a Cathode Ray tube.
- examine the motion of electrons in a magnetic field using a Cathode Ray tube.

Science, Technology and Society Connections

The students will:

- explain the following:
 - (i) magnets are often fitted to the doors of refrigerators and cupboards
 - (ii) a crane in a steelworks is fitted with a large electromagnet
 - (iii) wheat flour is usually passed near a magnet before being packed
 - (iv) a steel ship becomes magnetized as it is constructed
- explain how magnetic effect of a current has been put to the service of mankind in domestic life and in industry e.g.
 - (i) bullet train
 - (ii) an electromagnetic door lock
 - (iii) a circuit breaker
 - (iv) computers
 - (iv) credit cards
- analyse information and use available evidence to assess the impact of medical application of physics on society (e.g. identify the function of the electromagnetic field produced in the medical equipments)

magnetic resonance image(MRI) scans can be used to

 - detect cancerous tissues.
 - identify areas of high blood flow.
 - distinguish between gray and white matter in the brain.

Unit – 14 Electromagnetic Induction

Overview: Electricity and magnetism are two aspects of a single electromagnetic force. Moving electric charges produce magnetic forces and moving magnets produce electric forces. The interplay of electric and magnetic forces is the basis for electric motors, generators, and many other modern technologies.

The essential feature of an electric motor is the supply of electrical energy to a coil in a magnetic field causing it to rotate. The generation of electrical power requires relative motion between a magnetic field and a conductor. In a generator, mechanical energy is converted into electrical energy while the opposite occurs in an electric motor.

Major Concepts (18 periods)

- Induced Emf
- Faraday's law
- Lenz's law
- Eddy currents
- Mutual inductance
- Self-inductance
- Energy stored by an inductor
- Motional emf,s
- A.C. Generator
- A.C. motor and Back emf
- Transformer

Conceptual linkage:

↓ This chapter is built on
Electromagnetism Physics X

Learning Outcomes

Understanding

The students will:

- describe the production of electricity by magnetism.
- explain that induced emf's can be generated in two ways.
 - (i) by relative movement (the generator effect).
 - (ii) by changing a magnetic field (the transformer effect).
- infer the factors affecting the magnitude of the induced emf.
- state Faraday's law of electromagnetic induction.
- account for Lenz's law to predict the direction of an induced current and relate to the principle of conservation of energy.
- apply Faraday's law of electromagnetic induction and Lenz's law to solve problems.
- explain the production of eddy currents and identify their magnetic and heating effects.
- explain the need for laminated iron cores in electric motors, generators and transformers.
- explain what is meant by motional emf. Given a rod or wire moving through a magnetic field in a simple way, compute the potential difference across its ends.
- define mutual inductance (M) and self-inductance (L), and their unit henry.

- describe the main components of an A.C generator and explain how it works.
- describe the main features of an A.C electric motor and the role of each feature.
- explain the production of back emf in electric motors.
- describe the construction of a transformer and explain how it works.
- identify the relationship between the ratio of the number of turns in the primary and secondary coils and the ratio of primary to secondary voltages.
- describe how set-up and step-down transformers can be used to ensure efficient transfer of electricity along cables.

Investigation Skills/ Laboratory work

The students will:

- perform an investigation to predict and verify the effect on an electric current generated when:
 - the distance between the coil and magnet is varied.
 - the strength of the magnet is varied.
- demonstrate electromagnetic induction by a permanent magnet, coil and demonstration galvanometer.
- conduct a demonstration of step-up and step-down transformer by dissectible transformer.
- demonstrate an improvised electric motor.
- demonstrate the action of an induction coil by producing spark.
- gather information and choose equipment to investigate “multiplier “ effect (a small magnetic field created by current carrying loops of wire (wrapped around a piece of iron core lead to a large observed magnetic field).

Science, Technology and Society Connections

The students will:

- analyze and present information to explain how induction heating is used in furnaces to provide oxygen free heating environment.
- identify how eddy currents have been utilized in electromagnetic braking.
- analyze the earthquake detecting instrument – seismometer as a good example of an application of electromagnetic induction and explain
 - (i) any movement or vibration of the rock on which the seismometer rests (buried in a protective case) results in relative motion between the magnet and the coil (suspended by a spring from the frame).
 - (ii) the emf induced in the coil is directly proportional to the displacement associated with the earthquake.
- describe the use of step-down and step-up transformers for the electric supply from power station to houses and electric appliances at home.
- search and analyze information to identify how transmission lines are:
 - Insulated from supporting structure.
 - Protected from lightning strikes.

- explain that induction coil is a form of mutual inductor widely used to generate the high voltage sparks needed to ignite the petrol-air mixture in car and motorbike engines.
- assess that electric motors form the heart of a whole host of devices ranging from domestic appliances such as.
 - vacuum cleaners.
 - washing machines.
 - electric trains.
 - lifts.
 - in a car the wind screen wipers are usually driven by one and the engine is started by another.

Unit – 15 Alternating Current

Overview: The electricity produced by most generators is in the form of alternating current. In general AC generators, motors and other electrical equipments are simpler, cheaper and more reliable than their DC counterparts. AC electricity can be easily transformed into higher or lower voltages making it more versatile than DC electricity. Investigation of the behaviour of resistance, inductance and capacitance in AC circuits prepares us to look into the many diverse uses of these circuit elements and AC sources. A theory describing relation between accelerating charges, circuits and electric and magnetic fields was given by James Clerk Maxwell in 1864 called electromagnetic theory. The theory predicts that accelerating electric charges radiate electromagnetic waves, which propagate at the speed of light. When the acceleration is in the form of a continuous oscillation, the frequency of the electromagnetic waves is equal to the frequency of oscillation of the charges.

The carrier of the information is no longer a vehicle or person — rather, an increasing range of energy waves is used to transfer the message. The delay in relaying signals around the world is determined only by the speed of the wave, and the speed and efficiency of the coding and decoding devices at the departure and arrival points of the message. The time between sending and receiving messages through telecommunications networks is measured in fractions of a second allowing almost instantaneous delivery of messages, in spoken and coded forms, around the world.

This unit increases students' understanding of the nature, practice, application and uses of physics.

Major Concepts (27 periods)

- Alternating current (AC)
- Instantaneous, peak and rms values of AC
- Phase, phase lag and phase lead in AC
- AC through a resistor
- AC through a capacitor
- AC through an inductor
- Impedance
- RC series circuit
- RL series circuit
- Power in AC circuits
- Resonant circuits
- Electrocardiography
- Principle of metal detectors
- Maxwell's equations and electromagnetic waves (descriptive treatment)

Conceptual linkage:

↓ This chapter is built on
Electricity Physics X
ICT Physics X

Learning Outcomes

Understanding

The students will:

- describe the terms time period, frequency, instantaneous peak value and root mean square value of an alternating current and voltage.
- represent a sinusoidally alternating current or voltage by an equation of the form $x = x_0 \sin \omega t$.
- describe the phase of A.C and how phase lags and leads in A.C Circuits.
- identify inductors as important components of A.C circuits termed as chokes (devices which present a high resistance to alternating current).
- explain the flow of A.C through resistors, capacitors and inductors.
- apply the knowledge to calculate the reactances of capacitors and inductors.
- describe impedance as vector summation of resistances and reactances.
- construct phasor diagrams and carry out calculations on circuits including resistive and reactive components in series.
- solve the problems using the formulae of A.C Power.
- explain resonance in an A.C circuit and carry out calculations using the resonant frequency formulae.
- describe that maximum power is transferred when the impedances of source and load match to each other.
- describe the qualitative treatment of Maxwell's equations and production of electromagnetic waves.
- become familiar with electromagnetic spectrum (ranging from radiowaves to γ -rays).
- identify that light is a part of a continuous spectrum of electromagnetic waves all of which travel in vacuum with same speed.
- describe that the information can be transmitted by radiowaves.
- identify that the microwaves of a certain frequency cause heating when absorbed by water and cause burns when absorbed by body tissues.
- describe that ultra violet radiation can be produced by special lamps and that prolonged exposure to the Sun may cause skin cancer from ultra violet radiation.

Investigation Skills/ Laboratory work

The students will:

- determine the relation between current and capacitance when different capacitors are used in AC circuit using series and parallel combinations.
- measure DC and AC voltages by a CRO.
- determine the impedance of RL circuit at 50Hz and hence find inductance.
- determine the impedance of RC circuit at 50Hz and hence find capacitance.

Science, Technology and Society Connections

The students will:

- apply the use of infra red waves in radiant heaters, optical fibre commutations and for the remote control of TV sets and VCR's.
- describe the effect of ozone layer depletion.
- illustrate the principle of metal detectors used for security checks.
- state the principle of electro-cardiograph in medical diagnostic.
- describe the importance of oscillator circuit as broadcaster of radiowaves.
- describe the principle of resonance in tuning circuits of a radio.
- explain why transmission from some country TV channels are polarized at right angle to city channels.

Unit – 16 Physics of Solids

Overview: Materials have specific uses depending upon their characteristics and properties, such as, hardness, brittleness, ductility, malleability, conductivity etc. What makes steel hard, lead soft, iron magnetic and copper electrically conducting? It depends upon the structure – the particular order and bonding of atoms in a material. This clue has made it possible to design and creates materials with new and unusual properties for use in modern technology.

Major Concepts (13 periods)

- Classification of solids
- Mechanical properties of solids
- Elastic limit and yield strength
- Electrical properties of solids
- Superconductors
- Magnetic properties of solids

Conceptual linkage:

↓ This chapter is built on
Properties of matter Physics IX
Types of Solids Chemistry XI

Learning Outcomes

Understanding

The students will:

- distinguish between the structure of crystalline, glassy, amorphous and polymeric solids.
- describe that deformation in solids is caused by a force and that in one dimension, the deformation can be tensile or compressive.
- describe the behaviour of springs in terms of load-extension, Hooke's law and the spring constant.
- define and use the terms Young's modulus, bulk modulus and shear modulus.
- demonstrate knowledge of the force-extension graphs for typical ductile, brittle and polymeric materials.
- become familiar of ultimate tensile stress, elastic deformation and plastic deformation of a material.
- describe the idea about energy bands in solids.
- classify insulators, conductors, semiconductors on the basis of energy bands.
- become familiar with the behaviour of superconductors and their potential uses.
- distinguish between dia, para and ferro magnetic materials.
- describe the concepts of magnetic domains in a material.
- explain the Curie point.
- classify hard and soft ferromagnetic substances.
- describe hysteresis loss.
- synthesise from hysteresis loop how magnetic field strength varies with magnetizing current.

Investigation Skills/ Laboratory work

The students will:

- determine Young's modulus of the material of a given wire using Searle's apparatus.
- determine the energy stored in a spring.

Science, Technology and Society Connections

The students will:

- describe the applications of superconductors in magnetic resonance imaging (MRI), magnetic levitation trains, powerful but small electric motors and faster computer chips.
- identify the importance of hysteresis loop to select materials for their use to make them temporary magnets or permanent magnets.

Unit - 17 Electronics

Overview: The invention of the transistor by Bardeen, Brattain and Shockley paved the way for a wide range of new electronic devices. Transistor is the basis of the integrated circuits that run our computers and many modern technologies, including programmable controllers. Many modern technologies use electro-mechanical principles to interface real world sensors and outputs to microprocessors, temperature controllers. This unit increases students' understanding of the applications and uses of physics..

Major Concepts (16 periods)

- Intrinsic and extrinsic semiconductors
- P & N type substances
- Electrical conductivity by electrons and holes
- PN Junction
- Forward and reverse biased PN junction characteristics
- Half and full wave rectification
- Uses of specially designed PN junctions
- Transistor and its characteristics
- Transistor as an amplifier (C-E configuration)

Conceptual linkage:

↓ This chapter is built on
Introductory Electronics
Physics X

Learning outcomes

Understanding

The students will:

- distinguish between intrinsic and extrinsic semiconductors.
- distinguish between P & N type substances.
- explain the concept of holes and electrons in semiconductors.
- explain how electrons and holes flow across a junction.
- describe a PN junction and discuss its forward and reverse biasing.
- define rectification and describe the use of diodes for half and full wave rectifications.
- distinguish PNP & NPN transistors.
- describe the operations of transistors.
- deduce current equation and apply it to solve problems on transistors.
- explain the use of transistors as a switch and an amplifier.

Investigation Skills/ Laboratory work

The students will:

- draw characteristics of semiconductor diode and calculate forward and reverse current resistances.
- study the half and full wave rectification by semiconductor diodes by displaying on C.R.O.
- use multimeter to (i) identify base of transistor (ii) distinguish between NPN and PNP transistor (iii) see the unidirectional flow of current in case of diode and an LED. (iv) to check whether a given electric component e.g. diode or transistor is in working order.
- demonstrate the amplification action of a transistor graphically by CRO

Science, Technology and Society Connections

The students will:

- describe the function and use of LED, Photodiode and Photo voltaic cell.
- analyze that the modern world is the world of digital electronics.
- analyze that the computers are the forefront of electronic technology.
- realize that electronics is shifting low-tech electrical appliances to high-tech electronic appliances.

Unit-18 Dawn of the Modern Physics

Overview: In the early part of the twentieth century, many experimental and theoretical problems remained unresolved. Attempts to explain the behaviour of matter on the atomic level with the laws of classical physics were not successful. Phenomena such as blackbody radiation, the photoelectric effect and the emission of sharp spectral lines by atoms in a gas discharge tube could not be understood within the framework of classical physics. Between 1900 and 1930, a revolution took place and a new more generalised formulation called quantum mechanics was developed. This new approach was highly successful in explaining the behaviour of atoms, molecules and nuclei. As with special theory relativity, quantum theory requires a modification of ideas about the physical world.

In some circumstances (associated with its propagation) light exhibits the behaviour of waves, and in other circumstances (associated with its interaction with matter) it exhibits the behaviour of particles, prompting the question that forms the subject of this topic: whether or not electrons and other particles exhibit wave behaviour in similar circumstances.

A classic experiment, in which the interference effects of electrons were observed, is examined. The use of electrons as an alternative to light in microscopy is discussed as an application.

This unit increases students' understanding of the history, nature and practice of physics and developments in physics.

Major Concepts (24 periods)

- Special theory of relativity
- Quantum theory of radiation
- Photoelectric effect
- Compton's effect
- Pair production and pair annihilation
- Wave nature of particles
- Electron microscope
- Uncertainty Principle

Conceptual linkage:

↓ This chapter is built on
Planck's quantum theory
Chemistry XI
Resolving power, Magnifying
power of microscope Physics IX

Learning outcomes

Understanding

The students will:

- distinguish between inertial and non-inertial frames of reference.
- describe the significance of Einstein's assumption of the constancy of the speed of light.
- identify that if c is constant then space and time become relative.
- explain qualitatively and quantitatively the consequence of special relativity in relation to:
 - the relativity of simultaneity
 - the equivalence between mass and energy
 - length contraction

- time dilation
- mass increase
- explain the implications of mass increase, time dilation and length contraction for space travel.
- describe the concept of black body radiation.
- describe how energy is distributed over the wavelength range for several values of source temperature.
- describe the Planck's hypothesis that radiation emitted and absorbed by the walls of a black body cavity is quantised.
- elaborate the particle nature of electromagnetic radiation.
- describe the phenomenon of photoelectric effect.
- solve problems and analyse information using: $E = hf$ and $c = f \lambda$.
- identify data sources, gather, process and present information to summarise the use of the photoelectric effect in solar cells & photocells
- describe the confirmation of de Broglie's proposal by Davisson and Germer experiment in which the diffraction of electrons by the surface layers of a crystal lattice was observed.
- describe the impact of de Broglie's proposal that any kind of particle has both wave and particle properties.
- explain the particle model of light in terms of photons with particular energy and frequency.
- describe Compton effect qualitatively.
- explain the phenomena of pair production and pair annihilation.
- explain how the very short wavelength of electrons, and the ability to use electrons and magnetic fields to focus them, allows electron microscope to achieve very high resolution.
- describe uncertainty principle.

Investigation Skills/ Laboratory work

The students will:

- investigate the variation of electric current with intensity of incident light on a photocell.
- determine Planck's constant using internal potential barrier of different light emitting diodes.

Science, Technology and Society Connections

The students will:

- predict the motion of an object relative to a different frame of reference e.g. dropping a ball in a moving vehicle observed from the vehicle and by a person standing on the side walk.
- identify the role of special theory of relativity in global positioning , NAVSTAR system.
- summarize the use of solar cell and photoelectric cell in our daily life.
- search and describe the role of electron microscope to study the micro structures and properties of matter.

Unit – 19 Atomic Spectra

Overview: The beginning of the twentieth century saw the start of new branches of Physics – atomic structure and spectra which has a profound effect on revealing the inner mysteries of the structures of atoms.

The existence of line emission spectra from atomic gases is used to infer a structure of an atom in terms of discrete energy levels in atoms. J.J. Balmer in 1885 succeeded to devise an empirical formula which could explain the existence of the spectra of atomic hydrogen. Neil Bohr in 1913 provided a theoretical reasoning to Balmer formula explaining the emission of spectral lines by presenting a semi classical model of Hydrogen atom. Following this principle, the inner shells transition in heavy atoms should give rise to the emission of high energy photons or X-rays. The production of X-rays proved to be very beneficial in medical diagnostics. CAT scanner is an improved technique of X-rays which can detect tumours and other anomalies much too small to be seen with older techniques. Laser is another gift of research in this field. The laser beam is an intense, monochromatic and uni-directionally coherent, has many application in medical, industry, telecommunication and other fields.

Major Concepts (16 periods)

- Atomic spectra
- Emission of spectral lines
- Ionization and excitation potentials
- Inner shell transitions and characteristic X-rays
- Laser

Conceptual linkage:

↓ This chapter is built on
Atomic Structure
(Bohr Model) Chemistry XI

Learning Outcomes

Understanding

The students will:

- describe and explain the origin of different types of optical spectra.
- show an understanding of the existence of discrete electron energy levels in isolated atoms (e.g. atomic hydrogen) and deduce how this leads to spectral lines.
- explain how the uniqueness of the spectra of elements can be used to identify an element.
- analyse the significance of the hydrogen spectrum in the development of Bohr's model of the atom.
- explain hydrogen atom in terms of energy levels on the basis of Bohr Model.
- determine the ionization energy and various excitation energies of an atom using an energy level diagram.
- Solve problems and analyse information using.
- $1/\lambda = R_H [1/p^2 - 1/n^2]$.
- understand that inner shell transitions in heavy elements result into emission of characteristic X-rays.

- explain the terms spontaneous emission, stimulated emission, meta stable states, population inversion and laser action.
- describe the structure and purpose of the main components of a He-Ne gas laser.

Investigation Skills/ Laboratory work

The students will:

- observe the line spectrum of mercury with diffraction grating and spectrometer to determine the wavelength of several different lines, and hence draw a conclusion about the width of visible spectrum.
- examine the optical spectra by spectrometer and diffraction grating using different sources such as discharge tube (hydrogen, helium or neon) or of flames.

Science, Technology and Society Connections

The students will:

- describe the working of CT scanner.
- illustrate the use of laser in medicine, industry and holography.
- describe the useful properties of laser light and identify some of their uses.
- Identify the requirement for safe handling of lasers.

Unit – 20 Nuclear Physics

Overview: The composition of the nucleus is described in terms of protons and neutrons. The terminology and notation used to describe nuclei are introduced. Some of the fundamental conservation laws are used to discuss nuclear reactions.

The characteristics of nuclear fission reactions are discussed and applied to the example of a nuclear reactor used for the generation of electrical power. Energy can also be produced by nuclear fusion. Reference is made to the fusion reactions in stars, and some advantages and disadvantages of fusion as a future source of power. An attractive force which balances the electrostatic repulsive force between positively charged protons is identified.

Major Concepts (30 periods)

- Composition of atomic nuclei
- Isotopes
- Mass spectrograph
- Mass defect and binding energy
- Radioactivity (properties of α , β and γ rays)
- Energy from nuclear decay
- Half life and rate of decay
- Interaction of radiation with matter
- Radiation detectors (GM counter and solid state detector)
- Nuclear reactions
- Nuclear fission (fission chain reaction)
- Nuclear reactors (types of nuclear reactor)
- Nuclear fusion (nuclear reaction in the Sun)
- Radiation exposure
- Biological and medical uses of radiations (radiation therapy, diagnosis of diseases, tracers techniques)
- Basic forces of nature
- Elementary particles and particle classification (hadrons, leptons and quarks)

Conceptual linkage:

↓ This chapter is built on
Nuclear Physics X

Learning Outcomes

Understanding

The students will:

- describe a simple model for the atom to include protons, neutrons and electrons.
- Determine the number of protons, neutrons and nucleons it contains for the specification of a nucleus in the form ${}^A_Z X$.
- explain that an element can exist in various isotopic forms each with a different number of neutrons.
- explain the use of mass spectrograph to demonstrate the existence of isotopes and to measure their relative abundance.
- define the terms unified mass scale, mass defect and calculate binding

energy using Einstein's equation.

- illustrate graphically the variation of binding energy per nucleon with the mass number.
- explain the relevance of binding energy per nucleon to nuclear fusion and to nuclear fission.
- identify that some nuclei are unstable, give out radiation to get rid of excess energy and are said to be radioactive.
- describe that an element may change into another element when radioactivity occurs.
- identify the spontaneous and random nature of nuclear decay.
- describe the term half life and solve problems using the equation $\lambda = 0.693/T_{1/2}$.
- determine the release of energy from different nuclear reactions.
- explain that atomic number and mass number conserve in nuclear reactions.
- describe energy and mass conservation in simple reactions and in radioactive decay.
- describe the phenomena of nuclear fission and fusion.
- describe the fission chain reaction.
- describe the function of various components of a nuclear reactor.
- describe the interaction of nuclear radiation with matter.
- describe the use of Geiger Muller counter and solid state detectors to detect the radiations.
- describe the basic forces of nature.
- describe the key features and components of the standard model of matter including hadrons, leptons and quarks.

Investigation Skills/ Laboratory work

The students will:

- simulate the radioactive decay of nuclei using a set of at least 100 dice and measure the simulated half life of the nuclei.
- draw the characteristics curve of a Geiger Muller tube.
- determine the amount of background radiation in your surroundings and identify their possible sources.
- set up a G.M. point tube and show the detection of Alpha particles with the help of CRO and determine the count rate using a scalar unit.

Science, Technology and Society Connections

The students will:

- explain the basic principle of nuclear reactor.
- describe and discuss the function of the principle components of a water moderated power reactor (core, fuel, rods, moderator, control rods, heat exchange, safety rods and shielding).
- explain why the uranium fuel needs to be enriched.
- compare the amount of energy released in a fission reaction with the (given) energy released in a chemical reaction.
- describe how the conditions in the interiors of the Sun and other stars allow nuclear fusion to take place and hence, how nuclear fusion is their main energy conversion process.
- show an awareness about nuclear radiation exposure and biological effects of radiation.
- describe the term dosimetry.
- describe the use of radiations for medical diagnosis and therapy.
- explain the importance of limiting exposure to ionizing radiation.
- describe the examples of the use of radioactive tracers in medical diagnosis, agriculture and industry.

OBJECTIVES OF PRACTICAL WORK

Through experimental work the students are expected to develop the following skills:

A. Planning B. Implementing C. Interpreting and concluding

Students are required to carry out practical work as an integral part of the course. They are advised to maintain a laboratory record book in which they record, for all their practical work, the experimental arrangements used, the observations made and the analysis of these observations. Particular attention should be placed on the following:

1. Techniques

- (i) Reading to the maximum accuracy of linear and angular scales; use of vernier scales, timing by stopwatch or stopclock.
- (ii) Accurate focussing and location of images.
- (iii) Connecting up and checking electrical circuits from a circuit diagram, drawing a circuit diagram for a given simple circuit, already connected up.
- (iv) Recognize and respond to hazards.

(2) Information Handling

- (i) Display of results in tabular and graphical form.
- (ii) Translate information between graphical, numerical, algebraic and verbal forms.
- (iii) Accurate plotting with suitable choice of scales.
- (iv) For linear graph, determine the slope, intercept and intersection.
- (v) Choose, by inspection, a straight line which will serve as the best straight line through a set of data points presented graphically.
- (vi) Recall standard line form $y = mx + c$ and rearrange relationships into linear form where appropriate.
- (vii) Understand and use of area below a curve where the area has physical significance.

Note: Use of centimetre graph be made compulsory.

(3) Procedures

- (i) Making rough preliminary measurements and calculations where appropriate, e.g. assess the best range for accurate measurements, use an instrument of appropriate resolution, cooperate with other effectively describing the pattern of results and draw a valued conclusion.
- (ii) Careful recording of all actual measurements made.

(4) Order of Accuracy

- (i) Random and system errors.
- (ii) Meaning of absolute and relative (or percentage) error.
- (iii) Estimates of maximum error in simple cases.
- (iv) Common-sense appreciation of orders of accuracy of common measurements (not merely of scale readings) and ability to quote results to a number of significant figures reasonably in keeping with their estimated accuracy.

(5) Error Estimates

Rules for combination of maximum errors in the simple case;
 $x \pm y$, xy , x/y , x^n .

LIST OF PRACTICAL FOR GRADE XI

Standard experiments

- 1- Measure length and diameter of a solid cylinder and hence estimate its volume quoting proper number of significant figures using Vernier callipers.
- 2- Measure the diameters of a few ball bearings of different sizes using Screw Gauge and estimate their volumes. Mention the uncertainty in each result.
- 3- Determine the radius of curvature of convex lens and a concave lens using a spherometer.
- 4- Determine the weight of a body by vector addition of forces.
- 5- Verify the two conditions of equilibrium using a suspended metre rod.
- 6- Measure the free fall time of a ball using a ticker-timer and hence calculate the value of 'g'. Evaluate your result and identify the source of error and suggest improvements.
- 7- Investigate the value of 'g' by free fall method using electronic timer.
- 8- Investigate momentum conservation by colliding trolleys and ticker-timer for elastic and inelastic collisions.
- 9- Investigate the downward force, along an inclined plane, acting on a roller due to gravity and study its relationship with the angle of inclination by plotting graph between force and $\sin\theta$.
- 10- Determine the moment of inertia of a fly wheel.
- 11- Investigate the fall of spherical steel balls through a viscous medium and determine.
 - (i) terminal velocity
 - (ii) coefficient of viscosity of the fluid
- 12- Verify that the time period of the simple pendulum is directly proportional to the square root of its length and hence find the value of 'g' from the graph.
- 13- Determine the acceleration due to gravity by oscillating mass-spring system.
- 14- Determine the value of 'g' by vibrating a metal lamina suspending from different points.
- 15- Determination of frequency of A.C by Melde's apparatus / electric sonometer.

- 16- Investigation of the laws of vibration of stretched strings by sonometer or electromagnetic method.
- 17- Determine the wavelength of sound in air using stationary waves and to calculate the speed of sound using resonance tube.
- 18- Determine the wavelength of light by using a diffraction grating and spectrometer.
- 19- Determine the slit separation of a diffraction grating by using laser light of unknown wavelength.
- 20- Measure the diameter of a wire or hair using laser.
- 21- Determine the pick count of a nylon mesh by using a diffraction grating and a laser.
- 22- Measure the mechanical equivalent of heat by electric method.
- 23- Determine the specific heat of a solid by electrical method.

Note:

1. At least 20 standard practicals alongwith exercises are required to be performed during the course of studies of class XI.
2. Use of centimetre graph paper be made compulsory.

LIST OF PRACTICAL FOR GRADE XII

Standard experiments

1. Determine time constant by charging and discharging a capacitor through a resistor.
2. Determine resistance of wire by slide Wire Bridge.
3. Determine resistance of voltmeter by drawing graph between R and I/V .
4. Determine resistance of voltmeter by discharging a capacitor through it.
5. Analyse the variation of resistance of thermistor with temperature.
6. Determine internal resistance of a cell using potentiometer.
7. Determine emf of a cell using potentiometer.
8. Determine the emf and internal resistance of a cell by plotting V against I graph.
9. Investigate the relationship between current passing through a tungsten filament lamp and the potential applied across it.
10. Convert a galvanometer into voltmeter of range $0 - 3$ V.
11. Determine the relation between current and capacitance when different capacitors are used in AC circuit using different series and parallel combinations of capacitors.
12. Determine the impedance of a RL circuit at 50Hz and hence find inductance.
13. Determine the impedance of a RC circuit at 50Hz and hence find capacitance.
14. Determine Young's modulus of the material of a given wire using Searle's apparatus.
15. Draw characteristics of semiconductor diode and calculate forward and reverse current resistances.
16. Study the half and full wave rectification by semiconductor diodes by displaying on CRO
17. Study of the variation of electric current with intensity of light using a photocell.
18. Determine Planck's constant using internal potential barrier of different light emitting diodes.

19. Observe the line spectrum of mercury with diffraction grating and spectrometer to determine the wavelength of several different lines, and hence, draw a conclusion about the width of visible spectrum.
20. Using a set of at least 100 dice, simulate the radioactive decay of nuclei and measure the simulated half life of the nuclei.
21. Draw the characteristics curve of a Geiger Muller tube.
22. Determine the amount of background radiation in your surrounding and identify their possible sources.
23. Set up a G.M. point tube and show the detection of alpha particles with the help of CRO and determine the count rate using scaler unit.

Note:

1. At least 20 standard practical alongwith exercises are required to be performed during the course of studies of grade XII.
2. Use of centimetre graph paper be made compulsory.

LIST OF REQUIRED APPARATUS / EQUIPMENT FOR GRADE XI

Experiment No. Apparatus / Equipments

1. Vernier callipers, solid cylinder.
2. Micrometer screw gauge, ball bearings of different sizes.
3. Spherometer, a convex lens and a concave lens
4. Gravesand's apparatus or vector table, unknown weight, two hangers, slotted weights, spring balance, strip of plane mirror, thread, set squares, paper and $\frac{1}{2}$ metre rod.
5. Metre rod, wedge, two stands, set of slotted weights, two spring balances.
6. Steel ball, ticker-tape vibrator, roll of ticker-tape, transformer, sellotape.
7. Free fall apparatus, steel ball, electronic timer with power supply, plumb line and metre rod.
8. Two trolleys, smooth flat board 2 metres in length fitted with levelling screws and wooden bumpers at the two ends, trolley weights metre rod, spirit level, ticker tape-timer apparatus.
9. Variable inclined plane fitted with pulley, roller, weights, pan, stopwatch.
10. Flywheel, stopwatch, string, pan, different weights, metre rod, piece of chalk and a Vernier callipers.
11. A long glass plastic tube about 1 m long, glycerine, steel ball bearings of five or six different diameters, dilute caustic soda, tweezers, metre rod, paper collars, and rubber bands.
12. Simple pendulum, stopwatch, stand, thread, cork, Vernier callipers.
13. Helical spring, heavy iron stand, hanger, slotted weights, stopwatch.
14. Metal lamina, iron stand, stopwatch.
15. AC vibrator, step-down transformer (6V-A.C), connecting wire, stout cotton thread, pulley, and scale plan.
16. Sonometer, tuning forks of different frequencies, hanger, set of $\frac{1}{2}$ kilogram weights, wires of different diameters, scissors, sensitive balance, weight box and metre rod.

17. Resonance apparatus, two tuning forks of known frequency, thermometer, plumb line, Vernier callipers, cork or rubber pad, two set squares, beaker and water.
18. Spectrometer, diffraction grating, sodium lamp.
19. 1mW He-Ne laser source, diffraction grating, drawing board, a white screen, metre rod.
20. 1mW He-Ne laser source, thin wire and a suitable screen.
21. Nylon mesh fitted in wooden frame (used for screen printing), laser light, metre rule.
22. Electric calorimeter, $1/5$ °C thermometer, battery, rheostat, key, ammeter, voltmeter, connecting wires, stopwatch, balance and weight box.
23. Electric calorimeter, $1/5$ °C thermometer, battery rheostat, key ammeter, voltmeter, connecting wires, stopwatch, balance, weight box, unknown liquid.

LIST OF REQUIRED APPARATUS / EQUIPMENT FOR GRADE XII

Experiment No.	Apparatus / Equipment
1.	Galvanometer, power supply or battery, large value capacitor, key, stopwatch.
2.	Slide wire bridge, resistance box, unknown resistance, galvanometer, rheostat, cell, tapping key, connecting wires and sand paper.
3.	Voltmeter, resistance box, two keys, sand paper, connecting wires and graph paper.
4.	Voltmeter, power supply or battery, large value capacitor, key, stopwatch and slide wire bridge.
5.	Thermister, beaker, water, thermometer, slide wire bridge, resistance box, battery, galvanometer, rheostat, cell, tapping key, connecting wires, power supply or battery, large value capacitor, key, stop watch and slidewire bridge.
6.	Potentiometer, battery, ammeter, resistance box, rheostat, two keys, galvanometer, given cell, shunt wire, sand paper and connecting wires.
7.	Potentiometer, battery, tow-way key, rheostat, ammeter, key, shunt, wire, galvanometer, sand paper and connecting wires.
8.	Power supply or battery, voltmeter, ammeter, rheostat or resistance box or assorted resistors.
9.	36W, 12 volt car bulb, bulb holder, 12 volt battery, high resistance rheostat, voltmeter, ammeter, key, sand paper and connecting wires.
10.	Galvanometer, ammeter, standard voltmeter, accumulator, resistance box, plug key, rheostat, sand paper and connecting wires.
11.	A.C milliammeter, A.C voltmeter, capacitors of different capacitances $0.1 \mu\text{F}$, $0.2 \mu\text{F}$, $0.3 \mu\text{F}$, $0.4 \mu\text{F}$, $0.5 \mu\text{F}$, step-down transformer with tapings of 6, 12, volts or a variac, sand paper and connecting wires.
12.	R-L circuit, A.C power supply, step-down transformer, A.C Ammeter and A.C voltmeter.
13.	R-C circuit, A.C power supply, step-down transformer, A.C Ammeter and A.C voltmeter.
14.	Searle's apparatus, half kg slotted weights and metre rod.

15. A suitable semi conductor diode such as (IN 60), voltmeter (0 to 3V), voltmeter (0 to 50 V), milliammeter, micro ammeter, 500 ohms rheostat, 1 kilo ohm resistor, 3 volt battery, 0-250 volts continuously variable power supply, sand paper and connecting wires.
16. A.C power supply or step-down transformer, semiconductors diodes, circuit board, connecting wires and CRO.
17. Photocell, sensitive galvanometer, battery, rheostat, key, electric bulb preferably point-to-type lamp, suitable case for the bulb and photocell and connecting wires.
18. Spectrometer, L.E.D's fitted on board, power supply, diffraction grating.
19. Mercury lamp, spectrometer, diffraction grating,
20. 100 dice
21. Power supply, G.M tube with its holder and leads, scaler unit.
22. Geiger Muller tube (as Mullard MX 180), its tube holder and leads.
23. G.M point tube, α -source, CRO or scaler unit, power supply.

**LIST OF REQUIRED APPARATUS/EQUIPMENT FOR STANDARD EXPERIMENTS
AND EXERCISES PHYSICS FOR CLASSES XI-XII
(For a Class of 40 Students)**

Sr. No.	Apparatus/ Equipment	Quantity
1.	Gravesand's Apparatus or Vector Table	10
2.	Hanger	10
3.	Slotted Weights	10
4.	Solid Cylinder	10
5.	Plane Mirror Strip	24
6.	Metre rod	20
7.	Protractor	20
8.	Metallic bob	10
9.	Set square	10
10.	Ticker tape	5
11.	Power supply (AC & DC)	10
12.	Electric stopclock	5
13.	Frequency meter	5
14.	Electromagnet	5
15.	Two way switch	5
16.	Vernier Callipers	10
17.	Cork	1 pkt
18.	Stand with clamp	10
19.	Stopwatch	10
20.	Thread	5 spools
21.	Helical spring	20
22.	Slotted weights with hanger	20 sets
23.	Trolley	10
24.	Smooth plane wooden surface with adjustable screws	5
25.	Trolley weight (1 kg) set	10
26.	Ticker-timer	5
27.	Plasticine	5 pkt
28.	Resonance tube	10
29.	Glycerine	5 litre
30.	Steel ball bearings of different sizes	1 pkt

31.	Bar magnet	10
32.	Half kg. Slotted masses	5 sets
33.	Fly wheel	5 sets
34.	Melde's apparatus	5
35.	Rubber pad	10
36.	Tuning forks (480 & 512 Hz)	10
37.	Electric oscillator	10 each
38.	Sonometer	5
39.	Tubes (one sliding into other)	10
40.	Thermometer	10
41.	Iron stand with clamp	10
42.	Spectrometer	20
43.	He-Ne- gas laser	10
44.	CRO	5
45.	Microphone	5
46.	Diffraction grating	10
47.	Measuring tape	5
48.	Electric calorimeter	10
49.	Rheostat (low resistance)	10
50.	Rheostat (high resistance)	10
51.	Ammeter – (0-3A)	10
52.	Voltmeter (0-15V)	10
53.	Half degree thermometer	10
54.	Physical balance	4
55.	Weight box	4
56.	Meter bridge	10
57.	Galvanometer	10
58.	Dry cell	5 pkt
59.	Resistance box (high resistance)	10
60.	Resistance box (low resistance)	10
61.	Resistance box (fractional)	10
62.	Jockey	10
63.	Keys	10
64.	Thermistor	10

65.	Beaker (250, 500 cc)	10 each
66.	Screw guage	10
67.	Potentiometer	10
68.	Car bulb with holder	10
69.	12 Volts Battery	2
70.	Plotting compass	12
71.	Capacitors (1 μ F - 8 μ F)	10 sets
72.	Two way key	10
73.	Auto transformer	10
74.	Semiconductor diode	20
75.	Milli ammeter	10
76.	Micro ammeter	10
77.	NPN transistor	20
78.	Photo cell	10
79.	Wooden box	10
80.	Lamp	10
81.	Step-down transformer	10
82.	AC voltmeter	6
83.	Multimeter (digital)	6
84.	GM tube	2
85.	Scaler Unit	2
86.	Inclined plane with changeable inclination	6
87.	Steel Roller	6
88.	Metal Lamina	10
89.	Printing Screen Pieces (Used)	10
90.	Dice	150
91.	GM Point Tube	5
92.	Set of LEDs of different colours fitted on board	5
93.	Mercury Lamp	5
94.	Spherometer	10

Estimated Time Allocation and Weighting for Various Units/Chapters

Physics XI

Unit #	Content	Weighting in %age	Periods (Theory)	Periods Investigation / practical work
1.	Measurement	8	13	6
2.	Vectors and Equilibrium	10	14	6
3.	Forces and Motion	12	18	12
4.	Work and Energy	10	13	4
5.	Rotational and Circular Motion	12	18	3
6.	Fluid Dynamics	8	13	5
7.	Oscillations	9	14	9
8.	Waves	12	18	9
9.	Physical Optics	9	13	12
10.	Thermodynamics	10	16	6
		100	150	72

Physics XII

Unit #	Content	Weighting in %age	Periods (Theory)	Periods Investigation / practical work
11.	Electrostatics	12	18	3
12.	Current Electricity	10	15	21
13.	Electromagnetism	10	15	3
14.	Electromagnetic Induction	12	15	3
15.	Alternating Current	10	18	9
16.	Physics of Solids	7	10	3
17.	Electronics	7	10	6
18.	Dawn of the Modern Physics	10	18	6
19.	Atomic Spectra	10	13	3
20.	Nuclear Physics	12	18	12
		100	150	69

ASSESSMENT OBJECTIVES

The objectives of the examination are to assess students for the following abilities, skills and attitudes:

Knowledge and Understanding

Students should be able to:

- Recognize and use physics terms and concepts accurately.
- Explain phenomena, laws and models.
- Show awareness of instruments and apparatus including techniques of operation and aspects of safety.

Application

Students should be able to:

- Apply knowledge including principles of physics to everyday and unfamiliar/ novel situations.
- Apply knowledge including principles of physics to selected phenomena and applications.
- Apply knowledge including principles of physics in problem solving and experimental investigation using quantitative, numerical, theoretical and practical techniques.

Analysis

Students should be able to:

- Discriminate between relevant and irrelevant information.
- Interpret the recorded data.
- Use information to identify pattern, draw inferences and conclusions.
- Critically analyse information
- Analyze and synthesize information for the purpose of identifying problems for inquiry and solving the problems using a variety of skills.

Evaluation

Students should be able to:

- Evaluate information and hypothesis
- Draw valid conclusions from physics data
- Make predictions and put forward hypothesis
- Evaluate the result of an experiment

Communication

Students should be able to:

- Locate, select and present information in an organized and logical sequence from a variety of sources
- Identify and express ideas in physics clearly and concisely.
- Translate information from one form to another.
- Compile, organize and interpret data, using appropriate formats and treatment, including tables, flow charts, graphs and diagrams.

- Discuss issues relating to the social, economical, environmental and technological implications of physics

Experimental skills and investigations

Students should be able to:

- Become acquainted with basic instruments and measuring techniques and acquire the ability to select method, plan experiment, use material safely and effectively.
- Make observation and measurements with due regard for precision, accuracy and units.
- Understand the effect of uncertainty in a measurement on the final result.
- Interpret and evaluate observations and experimental data.
- Present and translate experimental data graphically.
- Analyze and interpret information and observations obtained in scientific and practical work. Identify patterns and trends and draw valid conclusions.

Attitudes

Students should acquire :

- An appreciation of the role of experimental work in the field of science.
- Concern for accuracy and precisions in investigations and practical work.
- Inquisitiveness and interest in their study of physics.

Glossary of Terms Used in Learning Outcomes/Assessment

It is hoped that the glossary will prove helpful to candidates as a guide, although it is not exhaustive. The glossary has been deliberately kept brief not only with respect to the number of terms included but also to the descriptions of their meanings. Candidates should appreciate that the meaning of a term must depend in part on its context. They should also note that the number of marks allocated for any part of a question is a guide to the depth of treatment required for the answer.

1. **Define (the term(s) ...)** is intended literally. Only a formal statement or equivalent paraphrase, such as the defining equation with symbols identified, being required.
2. **What is meant by ...** normally implies that a definition should be given, together with some relevant comment on the significance or context of the term(s) concerned, especially where two or more terms are included in the question. The amount of supplementary comment intended should be interpreted in the light of the indicated mark value.
3. **Explain** may imply reasoning or some reference to theory, depending on the context.
4. **State** implies a concise answer with little or no supporting argument, e.g. a numerical answer that can be obtained 'by inspection'.
5. **List** requires a number of points with no elaboration. Where a given number of points is specified, this should not be exceeded.
6. **Describe** requires candidates to state in words (using diagrams where appropriate) the main points of the topic. It is often used with reference either to particular phenomena or to particular experiments. In the former instance, the term usually implies that the answer should include reference to (visual) observations associated with the phenomena. The amount of description intended should be interpreted in the light of the indicated mark value.
7. **Discuss** requires candidates to give a critical account of the points involved in the topic.
8. **Deduce/Predict** implies that candidates are not expected to produce the required answer by recall but by making a logical connection between other pieces of information. Such information may be wholly given in the question or may depend on answers extracted in an earlier part of the question.
9. **Suggest** is used in two main contexts. It may either imply that there is no unique answer or that candidates are expected to apply their general knowledge to a 'novel' situation, one that formally may not be 'in the syllabus'.

10. **Calculate** is used when a numerical answer is required. In general, working should be shown.
11. **Measure** implies that the quantity concerned can be directly obtained from a suitable measuring instrument, e.g. length, using a rule, or angle, using a protractor.
12. **Determine** often implies that the quantity concerned cannot be measured directly but is obtained by calculation, substituting measured or known values of other quantities into a standard formula, e.g. the Young's modulus, relative molecular mass.
13. **Show** is used where a candidate is expected to derive a given result. It is important that the terms being used by candidates are stated explicitly and that all stages in the derivation are stated clearly.
14. **Estimate** implies a reasoned order of magnitude statement or calculation of the quantity concerned. Candidates should make such simplifying assumptions as may be necessary about points of principle and about the values of quantities not otherwise included in the question.
15. **Sketch**, when applied to graph work, implies that the shape and/or position of the curve need only be qualitatively correct. However, candidates should be aware that, depending on the context, some quantitative aspects may be looked for, e.g. passing through the origin, having an intercept, asymptote or discontinuity at a particular value. On a sketch graph, it is essential that candidates clearly indicate what is being plotted on each axis.
16. **Sketch**, when applied to diagrams, implies that a simple, freehand drawing is acceptable: nevertheless, care should be taken over proportions and the clear exposition of important details.
17. **Compare** requires candidates to provide both similarities and differences between things or concepts.

Acknowledgement: Extracted from Physics A/AS Level 2007 syllabus of Cambridge University, England

ASSESSMENT PATTERN XI-XII (PHYSICS)

The purposes of assessment is to measure the extent to which students have achieved the learning outcomes of the programme based on this curriculum statements.

An external examination is recommended at the end of each year. The syllabus division is suggested as shown below:

The Examination

The theory examination is suggested to consist of two parts each containing a wide variety of types of questions. Together the paper should be designed to examine the candidates' understanding of the whole syllabus and should test the following range of abilities.

Knowledge of Physics	15%
Understanding and problem solving in Physics	40%
Analysing, synthesizing and evaluation	25%
Communicating knowledge of Physics	20%

Paper - 1 (Part-I) Half an hour 20%	20 compulsory objective questions. This may include MCQ of various types to evaluate abilities and skills as detailed in Assessment objectives (a) and (b).
Paper - 1 (Part-II) 2 2½ hour Section-I 35% Section-II 30%	This paper should consist of two sections. Section I should contain ten compulsory short questions/constructed response questions to provide entire syllabus coverage and may consist of variable marks value to be answered in the space provided in the answer booklet and section II should contain 3 essay or comprehensive questions including numerical problems which may have choice of attempting 2 questions.
Paper-II Practical Test (2 hours) 15%	One practical exercise from a choice of two alternatives based to test the experimental and investigating skills given in Assessment objectives (C).

Note:(i) Assessment pattern is subject to the requirement, policies, and procedures of the Examination Boards.

- (ii) Question paper will be based on the curriculum not on a particular textbook.
- (iii) Questions involving unfamiliar contexts or daily life experiences may be set to assess candidates' problem-solving and higher-order processing skills. In answering such questions, sufficient information will be given for candidates

- to understand the situation or context. Candidates are expected to apply their knowledge and skills included in the syllabus to solve the problems.
- (iv) In general, SI units and terminology will be used.

It is suggested that in addition to the conduction of external examination, the teacher should evaluate class work on completion of each lesson/unit. One more internal examination during the course of each year should be conducted which may not be of more than one week duration each.

ASSESSMENT METHODS

1. The **selected response** - students select the answer to a question from two or more given choices. Such items are easy to develop. Their short response time allows more information to be assessed in a short time. However, since answer choices are provided, students can guess the correct answer without knowing the material. Scoring is quick and objective, since the teacher need only check if the single correct or best answer was identified for each item.
2. A **constructed response** format requires students to create or produce their own answer in response to a question or task. This allows teachers to gain insight into students' thinking and creative processes, and to assess higher order thinking. However, such items are time-consuming to answer and score. Although they eliminate guesswork, scoring is more subjective and thus clear criteria are necessary to maintain validity.

Essay Items may have students construct restricted-responses that limit the length, content and nature of the answer; or extended-responses that allow greater freedom in response.

Performance assessments require students to construct a more extensive response to a well-defined task, often involving real-world application of knowledge and skills.

SOME COMMONLY USED FORMATS

Selected Response

Multiple-Choice Items

Multiple choice items have a short question, followed by multiple answer choices from which students must pick the correct or the best answer. The question is called the stem, and the answer choices are called options. The options contain one correct or best answer, and two or more distractors.

Strengths and Weaknesses

- Relatively difficult to write, especially good distractors
- Having students pick the 'correct' answer assesses knowledge and understanding
- Having students pick the 'best' answer measures higher order thinking such as reasoning and critical analysis

- With answer choices provided, students focus on recognizing information rather than recalling or memorising it
- By evaluating students' wrong answers, teachers can see what students misunderstood or need clarified

Hints for designing better multiple-choice items (Teachers should be able to answer 'yes' to each checklist question).

- ✓ Does each stem contain a single, main problem stated simply and incorporating **all** the relevant information?
- ✓ Is each stem a question rather than an incomplete statement? (This prevents different grammar in the alternatives from giving away the correct answer).
- ✓ Have excess wordiness and overly complex language been avoided?
- ✓ Have negatives like "no," "never," "none," "not" been avoided? (Students tend to overlook these. If such words must be used, bold and/or capitalize them).
- ✓ Is the correct answer unquestionably right and complete? Is it the **ONLY** correct or best choice?
- ✓ Are all the options plausible or reasonable? Have obviously ridiculous options, options that say the same thing, or those that are clearly opposite in meaning, been revised? (Students should not be able to guess the answer by elimination).
- ✓ Are the options arranged systematically i.e. in alphabetical/chronological/numerical order? (This ensures students cannot guess the position of the correct answer).
- ✓ Are the number of options for each item appropriate to the students' age/grade levels? (2 or 3 options for lower grades and 4 or 5 options for older students).
- ✓ Have "clues" to the correct answer been avoided (making the correct option longer, more complex, or grammatically different from other options, using a/an to show if the correct option begins with a vowel)?
- ✓ Are all options for an item as brief and as clearly stated as possible? (measure knowledge not reading ability).
- ✓ Has "all of the above" been avoided as an option? (If students find one **WRONG** answer, "all of the above" cannot be correct. If students find two **RIGHT** answers "all of the above" must be correct).
- ✓ Has "none of the above" been avoided as an option?

Short Answer

Short-answer items are questions that call for students to write short answers (3-4 sentences at most), such as definitions or short responses.

Strengths and Weaknesses

- Good for assessing knowledge
- Can also assess understanding and reasoning
- Easy to construct since structure similar to instruction (question-and-answer) in class, so natural to teacher and student

Hints for designing better short answer items (Teachers should be able to answer 'yes' to each checklist question).

- ✓ Is it clear to the teacher whether knowledge, understanding or reasoning is being assessed?
- ✓ Are textbook questions avoided?
- ✓ Is the question brief and easy to understand?
- ✓ Is it clear to students that the answer must be short? (Use lines to indicate the maximum length of the answer)
- ✓ Is the specificity of the answer clear?

Essay Items

Such items literally have students answer a question by writing an essay. The length, nature and content of the essay is dependent on the question posed, so responses may be restricted or extended.

Strengths and Weaknesses

- Require students to sequence and integrate many separate ideas into a meaningful whole, interpret information, give arguments, give explanations, evaluate the merit of ideas, and conduct other types of reasoning
- Help students see themes, patterns, relationships
- Allow flexibility in responses
- Can evaluate students' ability to communicate their ideas
- Reading and scoring answers is time-consuming, especially if done so that meaningful feedback is given to students
- A single person, the teacher, judges the answers, so variations in mood, expectations, the order in which students are evaluated, and other factors, affect the professional judgments that are made
- Cannot assess lots of information or multiple reasoning skills at once

Hints for writing essay items (Teachers should be able to answer 'yes' to each checklist question).

- ✓ Can the targeted reasoning skill be measured by an essay (e.g. comparison, analysis, deduction etc)?
- ✓ Does the question clearly indicate the desired response? (students should know exactly what and how much information to use and should not be confused as to what aspect is asked for).
- ✓ Does the question allow for more than a right or wrong answer and/or process, justification, examples?
- ✓ Is there enough time to answer the questions?
- ✓ Are choices among several questions avoided?
- ✓ Has the teacher drafted many possible responses so she/he knows what to expect?
- ✓ Are the scoring criteria clear to teachers and students?

PART-III

INSTRUCTIONS AND SUGGESTIONS

GUIDELINES TO TEXTBOOK AUTHORS

An important dimension of curriculum is the translation of learning experiences or contents at the proper cognitive level of the target students. It is highly technical and delicate task to assist both teachers and students in learning and transmission of the life experiences. The concept to be introduced be explained informally before providing the formal definition or statement along with tangible examples from real life situation. The solved examples and the exercises should cover the whole range of variety of questions and their applications in the every day life. Keeping this strategy in view, the author should observe the following guidelines while writing the textbooks.

1. Learning objectives expected to be achieved in each chapter should be prominently stated at the beginning of the chapter.
2. Headings and sub headings should be clearly indicated.
3. Key words, terms and definitions should be highlighted in the text.
4. Concepts, application and relationships should be developed from concrete to abstract or simple to complex. Provide transition from previous information covered and new information presented.
5. The intended level and scope of treatment of each content/concept is defined by the desired learning outcomes identifying learning abilities, Investigation Skills/ Laboratory work and relevance with science, technology and society (STS). The intended learning outcomes mentioned under STS should preferably be developed through novel questions or numerical problems on real life situations.
6. The language used in the text should be concise and simple, consisting of short sentences using active tone and should be understandable to the students independently.
7. Ensure gender equity, textual matter urban/rural oriented and relevant to daily life.
8. The text should be supported with art i.e. illustrations and photographs possibly in colour which should be clear, properly labelled and captioned to make the substance interesting and stimulating.
9. Concepts, information and examples should match the sequence and content of learning outcomes.
10. The contributions of Muslim and Pakistani Scientists may be highlighted appropriately wherever related.
11. The text should be free from material repugnant to Islamic and Pakistani Ideology.
12. Examples and applications from local environment should be preferred.

13. SI units and terminology should be used all over in the text. However, conversion tables with other units can be given as additional information. Uniformity be maintained in symbolic representation of physical quantities and values of constants throughout in the text and in numerical problems.
14. Answers to the numerical problems should be quoted in scientific notation with correct number of significant figures and units.
15. Solved numerical examples and end of chapter numerical problems should be based on variety of situations in novel manner and be related to local environment, culture and real life situations.
16. Boxed “Tid bits”, “interesting information”, “do you know”, and “point of ponder” may be given to highlight additional information alongwith the description of concepts particularly related to STS connection through inquiry process.
17. Interesting sidelights such as case studies, discoveries, related technologies etc. may be given in the form of “boxed essays”.
18. Tables, flow charts/diagrams and concept maps may be given wherever appropriate.
19. Reference of the experiments given in the practical manual should be made with the related topics given in the text.
20. Coherent and precise summary should be given at the end of each chapter.
21. Several forms of questions/activities should be given at the end of each chapter. They should test not only knowledge but particularly the higher abilities such as understanding, handling information, analyzing, application of ideas and solving problems and relevant Investigation Skills/ Laboratory work and processes. For this purpose, there may be: ‘Self Quiz’ MCQs’, Review question, ‘Short questions’, Essay type questions, and thought /free response questions.
22. Some thought provoking questions may also be given within the chapter.
23. All questions should be very appropriately and clearly worded/constructed to test varying abilities and Investigation Skills on the basis of Bloom’s taxonomy.
24. The amount of information to be covered by the chapter must match the number of hours of instructional time.
25. A comprehensive glossary of terms and index should be given at the end of the book.
26. The teachers guide and workbooks should also be developed alongwith textbook which should include suitable strategies that a teacher can adopt for teaching a particular topic and should contain instructions how to explain a topic and how to show relevant demonstration.
27. A practical manual for the students should also be written to support practical work.

TEACHING METHODOLOGIES AND STRATEGIES

Effective and efficient delivery of knowledge is the main objective. There is a need to bring a paradigm shift in the process of teaching and learning by adopting the most modern teaching tools and techniques. The directive model is to be gradually replaced by the interactive and participative model, making a student an active learner. In addition to classroom lecturers, seminars, workshops, tutorials, study circles, presentations, case studies, investigating and mini projects and other similar techniques can be combined to achieve the objectives.

Be informed that physics should not be taken as a collection of facts, and teaching of Physics should not emphasize memorization of formal statements by rote, mechanical solution of problems by formulate or carrying out routine measurements by following given detailed instructions.

To present physics in a lively, exciting and intelligible way, emphasis should be placed on teaching for understanding by organized investigation, learning and discussion. A good demonstration can be used to stimulate learning. It is intended that consideration of everyday industrial and technological applications should pervade the course. Social, economic and environmental issues should also be considered where appropriate.

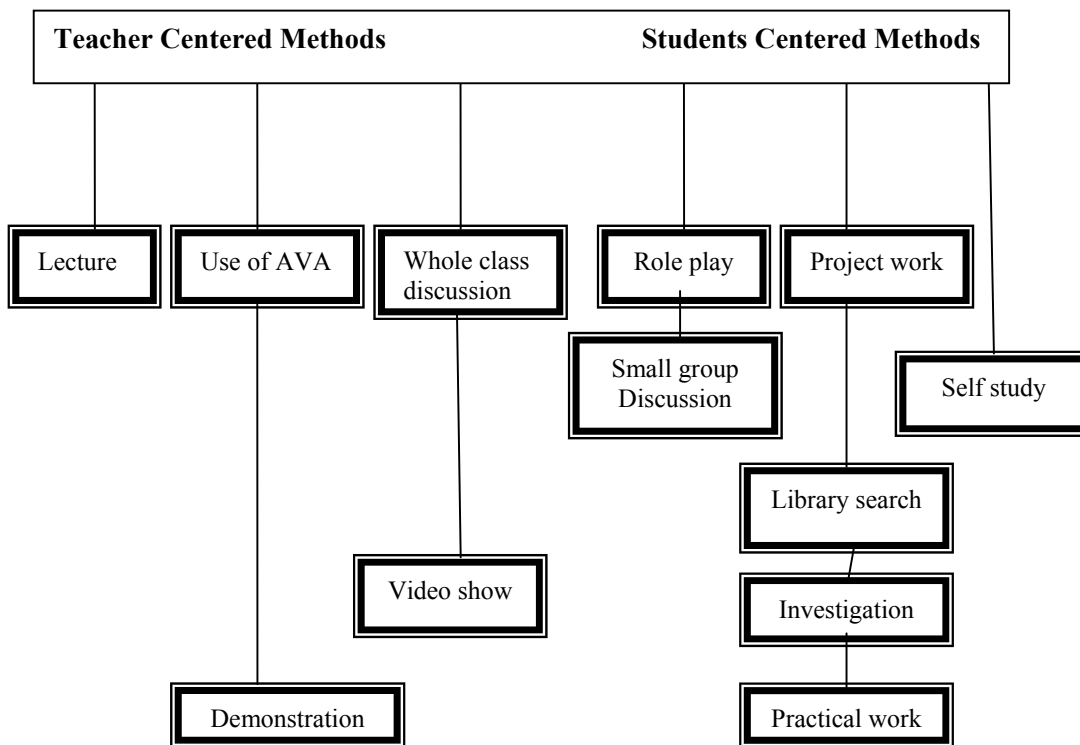
Quantitative treatment is a feature of physics. However, teacher must keep the emphasis on the understanding of the physical interpretation of theoretical formulate and experimental data.

An investigation approach to practical work is essential. Individual student project promotes creativity and demonstrate the students mastery of scientific principles involved. Independent use of apparatus by the students develop manipulative skills. The development of psychomotor skills such as correctly manipulating various instruments is an important objective of physics course.

Practical work is essential for students to gain personal experience of physics through doing and finding out. Another important objective of science teaching is to develop attitude of thinking in students. Teachers are encouraged to design their lessons in such a way that suitable questions and activities are incorporated in order to develop various types and levels of thinking in students, including analysis, evaluation, critical thinking and creative thinking.

Teachers capable in content areas may opt the teaching strategy that matches with psychology of the students. The strategy like posing problems, discussion, investigations, and solving the problems with the involvement of the students may provide an ample opportunity in conceptual clearance of a content.

Generally speaking, student centred and interactive approaches are useful in providing suitable learning experiences for stimulating and developing higher level thinking and are highly recommended. Teachers may consider to adopt a variety of strategies from the following spectrum which ranges from very teacher-centred methods to very students centred methods.



Spectrum of Teaching Methods

Teachers should choose appropriate teaching methods in accordance with the topic/skill to be taught as well as the interest and abilities of their students. The following are some factors to be considered when deciding on the teaching method for a particular topic.

- Learning objectives to be achieved
- Ability of student;
- Subject matter;
- Availability of resources; and
- Amount of time available

Role of E-media: Knowledge and technology needs to be shared freely on electronic media. It is time to look to the potential of ICT and digital technology beyond just the traditional technological sense.

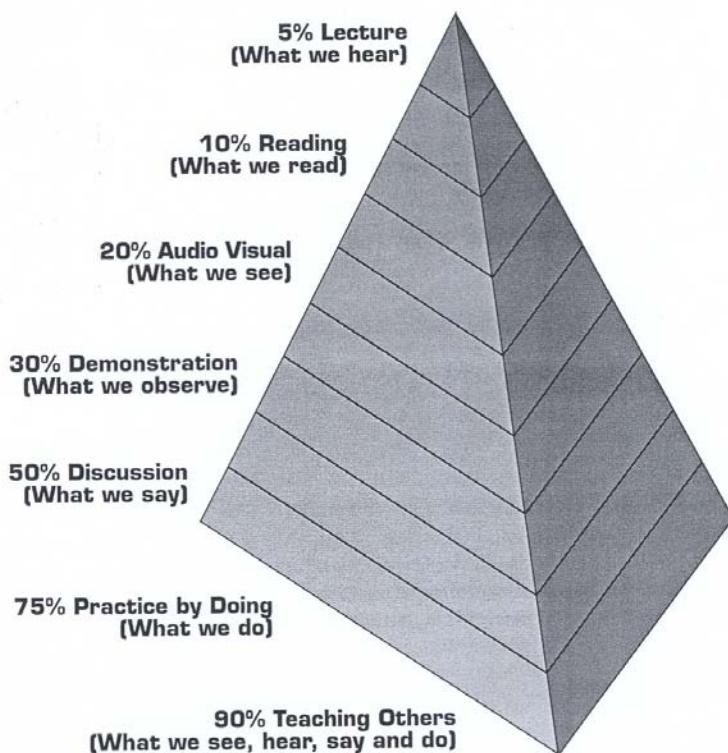
TEACHING / INSTRUCTIONAL STRATEGIES

Evidence from most Pakistani classrooms indicate that teaching and learning follows what Freire (1970) calls “The banking concept of education” in which teachers “transmit” textbook facts to students who are expected to memorize and regurgitate these facts in examinations. This practice has become so ingrained because teachers have themselves, as students, learned in this way, have been trained in this way, and have

found that the methods of lecture and recitation (teacher asks questions and student answers) are a good way of teaching the large number of students in their classrooms and assessing students ability to memorize textbook facts to ensure they do well in examinations.

There are many reasons for using instructional strategies other than lecture and recitation. First, research shows that students learn very little (5%) when taught through the lecture method. However, as their active intellectual engagement in the learning process increases they retain more of their learning. Second, living in the information age where knowledge is growing exponentially and facts are available at the click of a button students need to learn “how to learn”. Third, many instructional strategies besides facilitating students’ academic learning also aid development of a number of skills and values and promote their psychological health preparing them for the varied roles they will play in today’s society. Finally, in any class of students there will be a range of interests, abilities and styles learning. Varying the teaching strategies will address these differences allowing all children to learn.

The Learning Pyramid: Outcomes for Traditional Learning Methodology vs. Outcomes for Active / Experiential Learning Methodology



This section begins with the lecture methods as teachers are most familiar with and suggests ways to encourage students' participation in a lecture to improve learning.

EFFECTIVE LECTURING STRATEGY

A lecture is a method in which, the teacher transmits ideas, concepts and information to the students. A lecture allows teachers to transmit knowledge and explain key concepts in a limited time to a large group of students. The lack of active intellectual engagement by students could make the lecture boring so that students lose interest which hinders learning. Lecturing spoon-feeds the students without developing their power of reasoning. However, if used with different activities and exercises that call for students participation, the lecture can stimulate students intellectually and facilitate learning.

Developing an effective lecture

To deliver an effective lecture, the teacher must plan it. First, the teacher should identify the purpose of the lecture. The procedure of the lecture will follow from the purpose. If the purpose is to introduce new knowledge and concepts, the teacher can structure it in the classic way. However, if the purpose is to make students aware of different approaches to a particular problem, then the problem-oriented structure can be used.

In a classic lecture structure, the teacher outlines the purpose of the lecture and the main themes/subtopics that will be covered. Each theme/subtopic is then explained with examples. At the end, the teacher summarizes each theme/subtopic and concludes the lecture. A lecture can be made more effective by the use of diagrams, photos, graphics, etc. using charts, an overhead or multimedia projector.

In a problem-oriented lecture, the teacher states the problem and then offers one positive solution followed by a discussion of the weaknesses and strengths of the solution. Then he/she continues with the second solution and discusses its strengths and weaknesses. At the end, the teacher makes some concluding remarks.

Some ways to make a lecture interactive

Posing questions

In order to keep students engaged in a lecture, ask a question at the end of each theme/subtopic. This activity requires students to quickly process and use newly presented information to answer the question or solve the problem. Following the question give time to the students to come up with the answer, call on a few students to share their answers, sum up and move on. Some students out of fear of giving an incorrect response may not answer. To increase students participation use the Think-Pair-Share strategy; students think individually, share ideas with a colleague and then with the class. Sum up responses and move on. Alternatively, use Buzz groups. Buzz groups are small groups of three to five students who discuss the question before answering. Clear instructions regarding what to do, for how long and what is expected at the end of 'buzzing' must be given. After groups 'buzz', randomly choose students from 2-3 buzz groups to share their groups' discussion points or solutions. Sum up and move on.

Inviting students' questions

Before the lecture ask students if to share questions they want answers to and tailor lecture to answer them. Encourage students to ask questions on completion of each

theme/subtopic. Students' questions can be answered by the teacher or directed to the students inviting them to answer.

Assessing students' learning from a lecture

Students' learning can be assessed by asking students to answer questions orally or fill in a 'one-minute' worksheet which asks them to write down the 2-3 most important things they learnt in the lecture. Alternatively, students' notes on a lecture can be reviewed. A few days later a test could be given to find out what students learnt.

CONDUCTING INTERACTIVE DEMONSTRATIONS

In-class demonstrations have been considered a very important part of teaching science. Demonstrations can certainly make science classes fun and entertaining, and can also stimulate students' interest and curiosity. However, despite these positive aspects of demonstrations, there is a growing body of evidence suggesting that traditional in-class demonstrations are not very effective in promoting conceptual understanding. One important factor is the lack of active participation and interaction of students during demonstrations. Recent research studies indicate that students who saw traditional demonstrations in a course fared no better than students who did not see the demonstrations. The data do suggest, however, that there is at least a small improvement in performance when students have to predict the outcome of a demonstration before seeing it. Based on these and other studies, it has become increasingly clear that some form of interactive engagement is essential to maximize the effectiveness of classroom demonstrations.

Preparation

1. Determine the purpose of the demonstration and what you want to achieve.
 2. Conduct the demonstration yourself to ensure the results are as you want.
 3. Prepare curricular materials or worksheets and ensure they are designed to promote student-student as well as student-teacher interaction in the classroom.
 4. The problem-dissection technique is used to break a given demonstration into several conceptually linked mini-demonstrations.
 5. The mini-demonstrations are presented as a sequence in a pre-determined order. Breaking down the main demonstration into smaller component demonstrations is very effective in helping students construct a deeper understanding of physical concepts through step-by-step confrontation with their alternate conceptions.
 6. We utilize techniques (such as the use of flashcards, show of hands, for acquiring immediate feedback from all the students in the class.
-
1. Ask a question and have students predict the outcome of the demonstration by providing a response or selecting a response. They may provide or select a response before and/or after talking to their neighbours. For example, if we are exploring freely falling objects the question could be:

An one rupee coin and five rupees coin are dropped simultaneously from the same height. Which one will hit the floor first?

- A. One rupee coin will hit the floor first.
- B. Five rupees coin will hit the floor first.

- C. Both hit the floor at the same time.
- D. I am not sure/ I don't know.

2. Perform the demonstration
3. Once the first demonstration is complete have students complete their worksheet activities. Note: An interactive demonstration like the one described could be made up of a number of conceptually linked mini-demonstration to address important conceptual issues associated with free-fall and worksheet activities requires students to write predictions, draw motion diagrams and answer a set of multiple-choice questions..
4. Conduct a whole class discussion. Where necessary provide explanations to clarify or extend learnings.

DISCUSSION

Discussion is a unique form of group interaction where students join together to address a topic or questions regarding something they need to understand, appreciate or decide. They exchange and examine different views, experiences, ideas, opinions, reactions and conclusions with one another during the discussion. There are several benefits of discussion. Students increase their knowledge of the topic; explore a diversity of views which enables them to recognize and investigate their assumptions in the light of different perspectives; develop their communicative competence, listen attentively, speak distinctly and learn the art of democratic discourse.

Conducting a discussion

Preparation for discussion

Plan carefully by reviewing the material and choosing a question or a problem on a topic, framing it as interrogative question instead of a statement or a phrase. It is important that students have some knowledge of the topic chosen for discussion. Good ways of ensuring this are; asking students to read on the topic, interview concerned individuals, and engage in observation.

Conducting the discussion

Rearrange the classroom or move to another place (lab, playground) so students can sit in a circle or semicircle as it promotes better interaction between the students. Start by presenting the question orally and in writing it on the board to enable students to read and understand the question. Give students time to think and note down ideas in response to the question. Indicate the start of the discussion by repeating the question. While students share their own views and experiences or refer to their readings write down some answers so as to track and guide the discussion. During the discussion, ask probing questions such as “Why do you think?” “Can you elaborate further?” Or draw a conclusion and raise a new but related question. Give students the opportunity to participate and contribute to the discussion.

Concluding the discussion

Conclude the discussion by summarizing all the ideas shared and identifying questions for further inquiry or discussion. Summaries should be short but accurate.

Assessing students learning from a discussion

The knowledge, skills and values developed through discussion can be assessed using different assessment strategies. Use a checklist to record the presence or absence of desired behaviours such as presentation of factual research-based information, seeking clarifications, extending a idea presented, questioning one's assumptions, listening attentively, communicating clearly and openly and respecting others. Based on data the teacher can give feedback to the students for improvement. If the purpose is to assess students' knowledge and understanding, students could be asked to write an essay on the topic or answer test questions.

INQUIRY/INVESTIGATION

Inquiry/investigation is a process of framing questions, gathering information, analyzing it and drawing conclusions. An inquiry classroom is one where students take responsibility for their learning and are required to be active participants, searching for knowledge, thinking critically and solving problems. Inquiry develops students' knowledge of the topic of investigation inquiry, skills of questioning, hypothesizing, information gathering, critical thinking and presentation. They are also disposed to engaging in inquiry, open-mindedness and continuing their learning.

Teaching students to conduct an inquiry investigation

There are two main types of inquiry: knowledge-based inquiry and problem-based inquiry/investigation. Knowledge-based inquiry enables students to enhance their knowledge and understanding of content. Problem-based inquiry/investigation encourages study of social and scientific problems. If the study could lead to social action work with students to engage in responsible action.

There are a number of steps in conducting an inquiry/investigation. Each step is described below and an example of a knowledge inquiry and scientific investigation is provided below:

1. Choose a topic and have students frame inquiry questions(s) based on the topic or plan an investigation by developing materials yourself.
2. Have students formulate a hypothesis, i.e. provide possible explanations or educated guesses in answer to the questions.
3. Help students plan the inquiry. For example:
 - What is the best place to find information on the topic/What is the best way to gather data to solve the problem?
 - How to allocate time?
 - Whom to consult.?
4. Help students locate information/gather data.
5. Have students record information as they find it.
6. Help students evaluate their findings and draw conclusions. Students should look for relationships in the information gathered, analyze the information and try to answer of the inquiry question.
7. Have students communicate their findings in creative ways, written, oral and visual. For example, as a poster, article, talk show, role-play, etc.

8. Encourage student to suggest possible action based on findings. Select actions that are doable. Look at possible consequences of each action. Choose the best action.
9. Make an action plan and carry out the action.
10. Reflect on the success/challenges of the action.

Assessing learning from an inquiry/investigation

The process as well as products of an inquiry. Investigation must be assessed through the following:

- **Observation:** Students' abilities and skills can be observed during each stage of the inquiry/investigation. For example, you can observe a student conducting an interview, looking for relevant information in the library or making a graph. Teachers can provide detailed descriptive feedback to the students on their abilities and skills observed.

PROFESSIONAL DEVELOPMENT OF TEACHERS

Physics should be visualized as a vehicle to train a child to think critically and to articulate logically. It is a subject that is closely related to our society and environment. Students need to develop an awareness of the impact and role of physics in society and the environment and the interconnections between science, technology and society to live effectively in a world that is becoming increasingly scientific and technological.

An effective and meaningful physics education can only be ensured if the teacher, the key pivot of the change, is developed enough in contents as well as methodology. A teacher who has a sound knowledge of the subject, and adapting child-centered approach can do the justice to his profession by providing meaningful learning while poor delivery may cause disappointment, disenchantment and promote rote-learning.

Pre-service and in-service training may help the teachers to become familiar with a variety of strategies for successful delivery of the curriculum. In-service training providing exposure and sharing teaching-learning experiences will indeed help in developing the teaching force. During the course of training the teachers be posed open-ended problems related to real life situations for exploiting their potential and enhancing their interest and capabilities. The major purposes of in-service training in helping the teachers are to:

- a. improve teaching skills
- b. be aware of new innovations and strategies
- c. develop ability to conduct action research and
- d. enhance capability to specialize in specific subject

The curriculum development is a continuous process in all stages of education so is the process of updating the teacher education programmes at pre-service as well as at in-service stages. Probably, the changes in teacher training require greater insight and in-depth appreciation of all other changes to make these programmes more effective. If the teacher is not fully equipped and trained to handle the new curricula, the curriculum transaction would not be appropriate and consequently, the learning in school will be inadequate. Teacher education institutions (pre-service) have to continuously update their understanding of the curriculum process as well as the demands and expectations from the community on the educational system. The training stages have to be governed by both these considerations. The teacher is, however, no longer a mere transector of curriculum in the classroom, but its developer as well. Teaching Physics is replaced by learning physics, learning by doing, activity methods, child centred approach and others efforts are to be made to link it to the individuals life and his environment. Teacher's training needs the following actions:

1. Pre-service teacher training institutions be strengthened and their curricula be revised to meet the demands of fast changing and developing world.
2. In-service training is imparted in a number of ways. Workshops, seminars and extension lectures be organized more frequently and regularly and particularly in summer vacation. In-service training includes training in contents and

methodology. Practicing a tested methodology alone may not help much. Hence, content up-grading in the subject of physics has been realized as an urgent need for effective teaching of physics. Emphasis should specifically be laid on learner-centered and activity based approaches. Laboratory practices, classroom demonstration, active participation by the students whenever possible, and field interactions should become major components of the course.

3. The performance of participants in the courses of in-service training be monitored in the field and linked with their advancement in career.
4. A resource center at the training institutions be established for a ready help to the needy teachers. With the advent of electronic technology, the print matter is now receiving a lot of support from audio visual inputs. This needs to be exploited for the in-service of teachers. Lectures/demonstrations of eminent teachers could be prepared and made available for resource centres. The whole strategy will offer an opportunity of getting to interact with the best of learning materials for professional up-lift. Aids of all sorts are meant only to help in teaching and not to act as a substitute for teaching nor to replace the teacher. Aids make teaching realistic and effective, and these aids are meant to supplement the teaching. The effectiveness of the use of aids depends upon the skill of the teacher who has to examine the necessity and suitability of the aids.
5. A question bank be prepared which may consist of question based on Bloom's Taxonomy for assessing various abilities and skills.
6. A monthly publication of a journal can support instructional methodology/demonstrations, sharing teaching-learning experiences and other curriculum issues. Students' exposure to a wide variety of articles will also serve the purpose of broadening and enriching the curriculum. Students should be encouraged independently to read and write articles, popular essays on a variety of topics so that they can develop the ability to interpret, analyse and communicate scientific information.

PART-IV

SALIENT FEATURES – PHYSICS IX TO XII CURRICULUM 2006

Physics is a way of knowing, a process for gaining knowledge and understanding of the natural world. The course is designed to produce an integrated set of Learning Outcomes for students. As described in these, students will:

- Use science process and thinking skills.
- Manifest science interests and attitudes.
- Show an understanding of important science concepts and principles.
- Communicate effectively using science language and reasoning.

Coherent:

The Course has been designed so that, wherever possible, the science ideas taught within a particular class have a logical and conceptual linkage with each other and with those of earlier classes. Efforts have also been made to select topics and skills that integrate well with one another and with other subject areas appropriate to class level. In addition, there is an upward articulation of science concepts, skills, and content. This spiraling is intended to prepare students to understand and use more complex science concepts and skills as they advance through their science learning.

Outcome Based:

In order to specify the syllabus as precisely as possible and also to emphasize the importance of higher order abilities and skills, other than recall, learning outcomes have been used throughout. The intended level and scope of treatment of a content is defined by the stated learning outcomes with easily recognizable domain of (i) recalling, (ii) understanding, (iii) applying, (iv) analyzing, (v) evaluating and (vi) creating.

Cognitively Appropriate:

The Course takes into account the psychological and social readiness of students. It builds from concrete experiences to more abstract understandings. The course resists the temptation to describe abstract concepts at inappropriate class levels; rather, it focuses on providing experiences with concepts that students can explore and understand in depth to build a foundation for future science learning.

Encourages Interactive Teaching Practices:

It is difficult to accomplish the full intent of the Course by lecturing and having students read from textbooks. The Science Course emphasizes student inquiry. Science process skills are central in each standard. Good science encourages students to gain knowledge by doing science: observing, questioning, exploring, making and testing hypotheses, comparing predictions, evaluating data, and communicating conclusions. The Course is designed to encourage instruction with students working in cooperative groups.

Comprehensive:

Due care has been taken that the syllabus is not heavy and at the same time, it is comparable to the international standards. Overlapping of concepts within the discipline and with other disciplines have been eliminated to make room for contemporary core topics and emerging curricular areas.

The course provides a comprehensive background in science by emphasizing depth rather than breadth. The course seeks to empower students rather than intimidate them with a collection of isolated and forgettable facts.

Apart from need assessment, aims, objectives, core syllabus, the curriculum document also contains:

- (i) Chapter/unit wise weighting and time frame.
- (ii) Assessment objectives, glossary and examination pattern.
- (iii) List of standard practicals alongwith required equipment and a comprehensive list of equipment for a standard laboratory.
- (iv) General Instructions to authors.
- (v) Teaching strategies/methodologies.
- (vi) Suggestions for professional training/ capacity building of teachers.
- (vii) Implementation strategy.

Relevant:

The curriculum is harmonized with the national aspiration and needs. It is in consonance with the revised scheme of studies. The curriculum relates directly to student needs and interests. It is grounded in the natural world in which they live. The relevance and significance of concepts to students everyday life is given under the subhead "Science, Technology and Society" connections in every unit.

Character Builder:

Value for honesty, integrity, self-discipline, respect, responsibility, punctuality, cooperation, consideration, and teamwork are emphasized as an integral part of science learning. These relate to the care of living things, safety and concern for self and others, and environmental stewardship.

Effective, Flexible and Enjoyable:

Science instruction can cultivate and build on students' curiosity and sense of wonder. Effective science instruction engages students in enjoyable learning experiences. In a world of rapidly expanding knowledge and technology, all students need to gain the skills they will need to understand and function responsibly and successfully in the world. The Course provides skills in a context that enables students to experience the joy of doing science.

Encourages Thinking and Problem Solving Based Assessment:

Student achievement of the standards and objectives in this Course is best assessed using a variety of assessment instruments. Performance tests are particularly appropriate to evaluate student mastery of science processes and problem-solving skills.

NATIONAL CURRICULUM DEVELOPMENT TEAM

1. Prof. Muhammad Ali Shahid, Izaz-i-Fazeelat,
M.Sc. (Pb), CPhys (U.K), M Inst P. (London), MAAPT (New York)
Director (Technical),
Punjab Textbook Board, Lahore
2. Mr. Chiragh Din Arif,
Additional Director (Curriculum Wing), Punjab Textbook Board, Lahore
3. Mrs. Nazma Sheikh, Sr. Subject Specialist (Physics),
Punjab Textbook Board (PTB), Lahore
4. Mr. Qaisar Saleem Akhtar,
Subject Specialist (Physics), PTB, Lahore
5. Mr. Aamer Raiz,
Research Associate (Physics),(C.W), PTB, Lahore
6. Mr. Abdul Rauf Zahid,
Asstt. Subject Specialist (Physics) PTB Lahore
7. Mrs. Yasmin Faisal Wyne, Subject Specialist,
Provincial Institute of Teacher Education, Wahdat Road, Lahore
8. Mr. Muhammad Shakoor, M.Sc. (Physics)
Headmaster, Crescent Model School, Lahore
9. Prof. Fayyaz Mahmood, (Rtd)
Head of Physics Department, Government College of Science, Lahore.
10. Mrs. Tauseef Saeed, Associate Professor of Physics,
Government Islamia College for Women, Cooper Road, Lahore
11. Mr. Jawaid Tariq, Associate Professor (Physics),
Government College of Science, Wahdat Road, Lahore
12. Syed Muhammad Mujahid Haider, M.Sc.,Curriculum Development Centre
(Physics), Beaconhouse School System, Lahore

TEAM OF ADVISORS

1. Prof. Dr. M. Zakria Butt (T.I), Ph. D, UK
Chairman, Board of Intermediate & Secondary Education, Lahore
2. Sheikh Aftab Ahmad, Professor of Physics,
Government College University, Lahore
3. Dr. Cusrow J. Dubash,
Vice Rector Forman Christian College (A Chartered University), Lahore
4. Dr. S. A. Chaudhry, Ph.D (Physics) UK
Foreign Faculty Professor, Quality Management and Technology. Punjab
University, Lahore