

National Curriculum for

PHYSICS

Grades IX – X

2006



**GOVERNMENT OF PAKISTAN
MINISTRY OF EDUCATION
ISLAMABAD**

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PART-I

PREAMBLE

INTRODUCTION

The secondary school education is crucial and challenging, being a transition level from general science to discipline based curriculum. At this level, the students take up physics, as a discipline, with a purpose of pursuing their future careers in basic sciences or pre-professional courses like medicine, engineering and technology at the higher level. Hence, there is a need to provide the learners with sufficient conceptual background of physics which would eventually make them competent to meet the challenges of academic and pre-professional courses after the secondary level.

RATIONALE

The present effort of revising and updating the physics curriculum is an exercise based on the feedback received on the curriculum and course material in vogue, expansion of frontiers of physics knowledge, a paradigm shift due to emerging trends of teaching - learning process towards interactive and participative approach, making a student an active and independent learner.

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 the 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 given to promote process-Investigation Skills/ Laboratory work, problem-solving abilities and application of concepts, useful in real life situations for making physics learning more relevant, meaningful and stimulating.

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 objectives and pattern.
10. Drafting suggestions on the other components of curriculum such as
 - (a) Instructions for writing teaching-learning materials/ textbooks,
 - (b) Concept mapping
 - (c) Teaching strategies and methodology
 - (d) Teachers training
11. Identification of salient features of National Physics Curriculum.

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 schools by Mr. C.D. Arif, Additional Director (Curriculum Wing), Punjab Textbook Board.
 - (a) Govt. Pilot Secondary School (Boys), Wahdat Road, Lahore
 - (b) Govt. Pilot Secondary School (Girls), Wahdat Road, Lahore
 - (c) Govt. Boys High School, Karim Block, AIT, Lahore
2. Critical Review of National Curriculum Physics IX-X (2000) by Mr. Majahid Haider, Beaconhouse School System

- 3 Critical Review of National Curriculum Physics IX-X (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. Muhammd Ismail Zareef, Crescent Model Higher Secondary School, Lahore
- 6 Feedback from Students and Teachers Govt. Pilot Secondary School, Wahdat Road, Lahore by Mr. Muhammad Firdious, S.S.T.

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 Investigation Skills/ Laboratory work 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 Investigation Skills/ Laboratory work 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 O 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 IX-X
- 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.

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 the physics course at secondary school level are to enable student to:

1. develop interest, motivation and sense of achievement in the study of physics
2. develop the ability to describe and explain concepts, principles, systems, processes and applications related to physics.
3. develop the thinking process, imagination, ability to solve problems, data management, investigating and communication skills.
4. develop an attitude of responsible citizenship, including respect for the environment and commitment to the wise use of resources.
5. recognize the usefulness and limitations of scientific method and the interaction between science, technology and society

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 Investigation Skills/ Laboratory work 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 five main themes/sections with overview of each section. Each section is further divided into “units” showing their conceptual linkages.

In order to specify the syllabus as precisely as possible and also to emphasize the importance of higher order abilities and Investigation Skills/ Laboratory work 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 “**Investigation Skills/ Laboratory work**” measuring, observing, manipulating, recording and interpreting /analyzing, predicting and **communicating abilities/ Investigation 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 AND 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 lead 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.

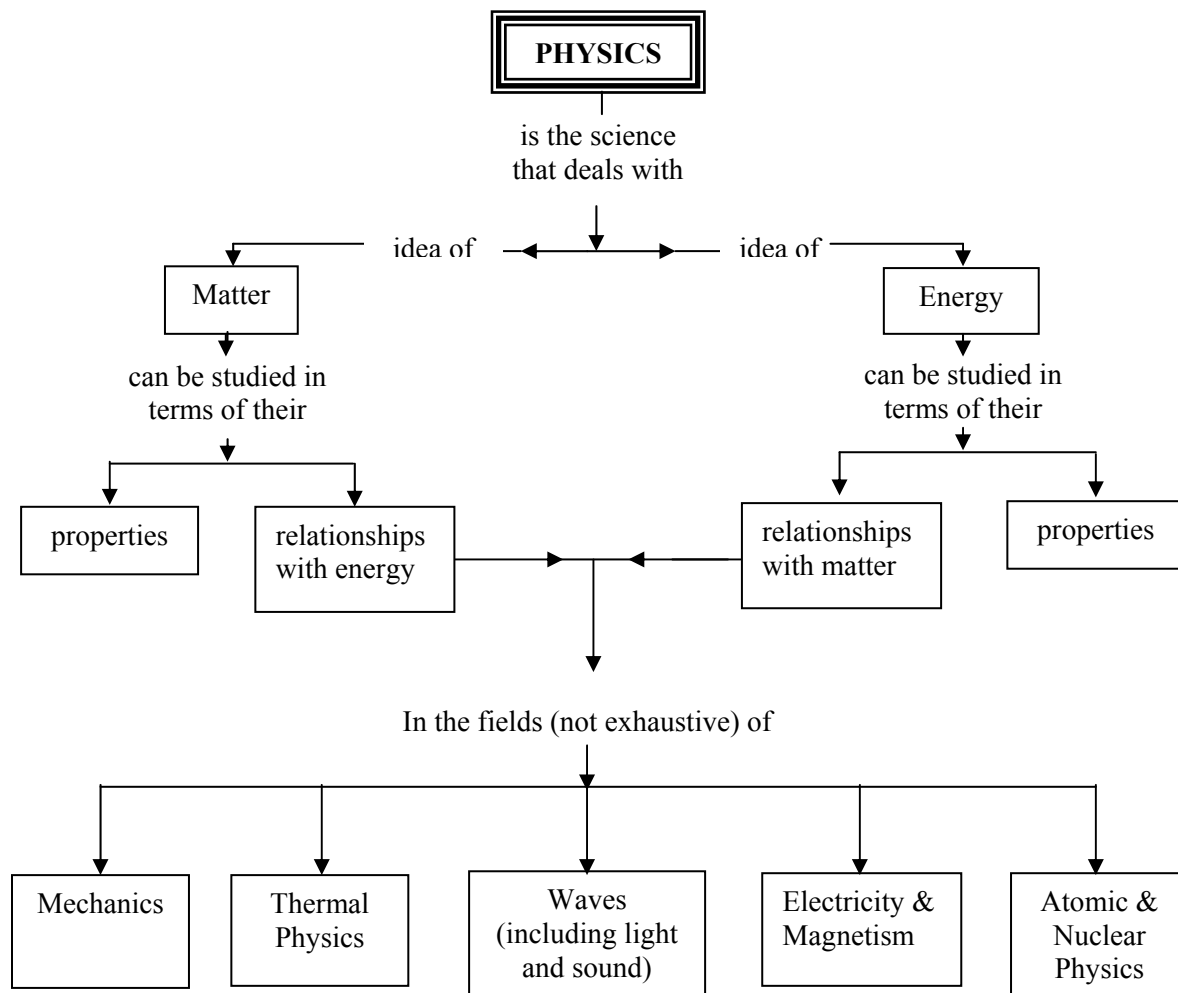
BENCHMARKS

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	Demonstrate an understanding of the principles related to fluid dynamics and their applications.

	in hydraulic systems.	
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.

Concept Map of Physics IX – X



LIST OF SECTIONS & UNITS IX-X

Section-1	Mechanics	1. Physical quantities and measurement
		2. Kinematics
		3. Dynamics
		4. Turning effect of forces
		5. Gravitation
		6. Work and Energy
		7. Properties of matter
Section-2	Heat	8. Thermal properties of matter
		9. Transfer of heat
Section-3	Oscillations and Waves	10. Simple harmonic motion and waves
		11. Sound
		12. Geometrical optics
Section-4	Electricity and Magnetism	13. Electrostatics
		14. Current electricity
		15. Electromagnetism
		16. Introductory electronics
		17. Information & communication Technology
Section-5	Atomic & Nuclear Physics	18. Radioactivity

Section 1 Mechanics

Overview: In this section, fundamental concepts of mechanics are introduced. Students are expected to possess experimental Investigation Skills/ Laboratory work in time measurement and in the recording of displacement, velocities and acceleration of objects using suitable measuring instruments. Investigation Skills/ Laboratory work in the measurement of masses, weights and forces are also required. Data handling Investigation Skills/ Laboratory work such as the conversion of displacement data into information on velocity or acceleration are expected. Students should be able to display experimental results in an appropriate form, interpret and analyse motion and draw valid conclusions. In particular, students should be able to plot graphs with an appropriate scale and interpret the significance of slopes, intercepts and areas in certain graphs.

The characteristics of gravitational force are also examined in this section. Newton's law of universal gravitation is introduced and used to extend the study of uniform circular motion to the centripetal acceleration caused by the gravitational force on a satellite.

UNIT # 1 Physical Quantities and Measurement

The following concepts are developed in this unit. Their intended level and scope is defined by the learning outcomes.

Major Concepts (21 periods)

- Introduction to Physics
- Physical quantities
- International system of units
- Prefixes (multiples and sub multiples)
- Standard form / scientific notation
- Measuring instruments
 1. metre rule
 2. vernier callipers
 3. screw gauge
 4. physical balance
 5. stopwatch
 6. measuring cylinder
- An introduction to significant figures

Conceptual linkage:

↴ This chapter is built on
Measurement – Science-VIII.
Scientific Notation Maths IX

↴ This chapter leads to:
Measurement –Physics XI

➤ Learning outcomes:

Understanding

The students will:

- describe the crucial role of Physics in Science, Technology and Society.
- explain with examples that Science is based on physical quantities which consist of numerical magnitude and a unit.
- differentiate between base and derived physical quantities.

- list the seven units of System International (SI) alongwith their symbols and physical quantities (standard definitions of SI units are not required).
- interconvert the prefixes and their symbols to indicate multiple and sub-multiple for both base and derived units.
- write the answer in scientific notation in measurements and calculations.
- describe the working of vernier callipers and screw gauge for measuring length.
- identify and explain the limitation of measuring instruments such as metre rule, vernier callipers and screw gauge.
- describe the need using significant figures for recording and stating results in the laboratory.

Investigation Skills/ Laboratory work

The students will:

- compare the least count/ accuracy of the following measuring instruments and state their measuring range:
 - i. Measuring tape
 - ii. Metre rule
 - iii. Vernier callipers
 - iv. Micrometer screw gauge
- make a paper scale of given least count e.g. 0.2 cm and 0.5 cm.
- determine the area of cross section of a solid cylinder with vernier callipers and screw gauge and evaluate which measurement is more precise.
- measure length and diameter of a cylinder and calculate the volume with a vernier callipers.
- measure the thickness of a metal strip or a wire using a screw gauge.
- determine an interval of time using stopwatch
- determine the mass of an object by using different types of balances and identify the most accurate balance.
- determine volume of an irregular shaped object using a measuring cylinder.
- list laboratory safety equipments and rules.
- use appropriately safety equipments in the laboratory.

Science, Technology and Society Connections

The students will:

- determine length, mass, time and volume in daily life activities using various measuring instruments .
- list with brief description the various branches of physics.

UNIT # 2

Kinematics

Major Concepts (19 periods)

- Rest and motion
- Type of motion (Translatory, rotatory, vibratory)
- Terms associated with motion;
 - Position
 - Distance and displacement
 - Speed and velocity
 - Acceleration
- Scalars and Vectors
- Graphical analysis of Motion;
 - Distance-time graph
 - Speed-time graph
- Equations of Motion;
 - $S = vt$
 - $v_f = v_i + at$
 - $S = v_i t + \frac{1}{2} at^2$
 - $v_f^2 - v_i^2 = 2 a S$
- Motion due to gravity

Conceptual linkage:

↓ This chapter is built on
Force and Motion science IV

↓ This chapter leads to
Motion and force physics XI

Learning Outcomes:

Understanding

The students will:

- describe using examples how objects can be at rest and in motion simultaneously.
- identify different types of motion i.e; translatory, (linear, random, and circular); rotatory and vibratory motions and distinguish among them.
- differentiate with examples between distance and displacement, speed and velocity.
- differentiate with examples between scalar and vector quantities.
- represent vector quantities by drawing.
- define the term speed, velocity and acceleration.
- plot and interpret distance-time graph and speed-time graph.
- determine and interpret the slope of distance-time and speed-time graph.
- determine from the shape of the graph, the state of a body.
 - i. at rest ii. moving with constant speed iii. moving with variable speed.
- calculate the area under speed-time graph to determine the distance traveled by the moving body.
- derive equations of motion for a body moving with a uniform acceleration in a straight line using graph.
- solve problems related to uniformly accelerated motion using appropriate equations.
- solve problems related to freely falling bodies using 10 ms^{-2} as the acceleration due to gravity.

➤ Investigation Skills/ Laboratory work

The students will:

- demonstrate various types of motion so as to distinguish between translatory, rotatory and vibratory motions.
- measure the average speed of a 100 m sprinter
- determine the acceleration of free-fall by timing a falling object by free fall apparatus.
- calculate the acceleration down an inclined surface of an iron ball using angle iron by drawing $2S$ and t^2 graph.

➤ Science, Technology and Society Connection

The students will:

- list the effects of various means of transportations and their safety issues.
- the use of mathematical slopes (ramps) of graphs or straight lines in real life applications.
- interpret graph from newspaper, magazine regarding cricket and weather etc.

UNIT # 3

Dynamics

Major Concepts (21 periods)

- Momentum
- Newton's laws of motion
- Friction
- Uniform circular motion

➤ Learning Outcomes:

Conceptual linkage

↳ This unit is built on
Force-Science IV,
Friction Science V

↳ This unit leads to
Motion & force Physics XI

Understanding

The students will:

- define momentum, force, inertia, friction, centripetal force.
- solve problem using the equation Force = change in momentum / change in time.
- explain the concept of force by practical examples of daily life.
- state Newton's laws of motion.
- distinguish between mass and weight and solve problem using $F = ma$, and $w = mg$.
- calculate tension and acceleration in a string during motion of bodies connected by the string and passing over frictionless pulley using second law of motion.
- state the law of conservation of momentum.
- use the principle of conservation of momentum in the collision of two objects.
- determine the velocity after collision of two objects using the law of conservation of momentum.
- explain the effect of friction on the motion of a vehicle in the context of tyre surface, road conditions including skidding, braking force.
- demonstrate that rolling friction is much lesser than sliding friction.
- list various methods to reduce friction.
- explain that motion in a curved path is due to a perpendicular force on a body than changes direction of motion but not speed.
- calculate centripetal force on a body moving in a circle using mv^2/r .
- state what will happen to you while you are sitting inside a bus when the bus
 1. starts moving suddenly
 2. stops moving suddenly
 3. turns a corner to the left suddenly
- write a story about what may happen to you when you dream that all frictions suddenly disappeared. Why did your dream turn into a nightmare?"

➤ Investigation Skills/ Laboratory Work

The students will:

- identify the relationship between load and friction by sliding a trolley carrying different loads with the help of a spring balance on different surfaces.
- determine the value of "g" by Atwood's machine.

- investigate the relationship between force of limiting friction and normal reaction to find the co-efficient of sliding friction between a wooden block and horizontal surface.
- determine the force of limiting friction by rolling a roller on a horizontal plane.

↗Science, Technology and Society Connections

The students will:

- identify the principle of dynamics with reference to the motion of human beings, objects, and vehicles (e.g. analyse the throwing of a ball, swimming, boating and rocket motion).
- identify the safety devices (such as packaging of fragile objects, the action of crumple zones and seatbelts) utilized to reduce the effects of changing momentum.
- describe advantages and disadvantages of friction in real – world situations, as well as methods used to increase or reduce friction in these situations (e.g. advantages of friction on the surface of car tyres (tyre tread), cycling, parachute, knots in string; disadvantages of, and methods for reducing friction between moving parts of industrial machines and on wheels spinning on axles).
- identify the use of centripetal force in (i) safe driving by banking roads (ii) washing machine dryer (iii) cream separator.

UNIT # 4

Turning Effect of Forces

Major Concepts (20 periods)

- Forces on bodies
- Addition of forces
- Resolution of forces
- Moment of a force
- Principle of moments
- Centre of mass
- Couple
- Equilibrium
- Stability

Conceptual linkage:

↓ This chapter is built on
Lever Science V
Machines Science VI
Kinematics Physics IX
Mathematics Trigonometry IX

↓ This chapter leads to
Rotational Motion Physics XI
Vectors and Equilibrium
Physics XI

Learning Outcomes

Understanding

The students will:

- define like and unlike parallel forces.
- state head to tail rule of vector addition of forces/vectors.
- describe how a force is resolved into its perpendicular components.
- determine the magnitude and direction of a force from its perpendicular components.
- define moment of force or torque as $\text{moment} = \text{force} \times \text{perpendicular distance from pivot to the line of action of force}$.
- explain the turning effect of force by relating it to everyday life.
- state the principle of moments.
- define the centre of mass and centre of gravity of a body.
- define couple as a pair of forces tending to produce rotation.
- prove that the couple has the same moments about all points.
- define equilibrium and classify its types by quoting examples from everyday life.
- state the two conditions for equilibrium of a body.
- solve problems on simple balanced systems when bodies are supported by one pivot only.
- describe the states of equilibrium and classify them with common examples.
- explain effect of the position of the centre of mass on the stability of simple objects.

Investigation Skills/ Laboratory work

The students will:

- determine the position of centre of mass/gravity of regularly and irregularly shaped objects.
- verify the principle of moments by using a metre rod balanced on a wedge.
- determine the tension in strings by balancing a metre rod on two stands.

- determine the weight of an unknown object by using vector addition of forces.
- determine the weight of an unknown object by using principle of moments

➤ Science, Technology and Society Connections

The students will:

- illustrate by describing a practical application of moment of force in the working of bottle opener, spanner, door/windows handles etc.
- describe the working principle of see-saw.
- demonstrate the role of couple in the steering wheels and bicycle pedals.
- demonstrate through a balancing toy, racing car etc. that the stability of an object can be improved by lowering the centre of mass and increasing the base area of the objects.

UNIT # 5

Gravitation

Major Concepts (16 periods)

- Law of gravitation
- Measurement of mass of earth
- Variation of 'g' with altitude
- Motion of artificial satellites (simple treatment)

➤ Learning outcomes

Understanding

The students will:

- state Newton's law of gravitation.
- explain that the gravitational forces are consistent with Newton's third law.
- explain gravitational field as an example of field of force.
- define weight (as the force on an object due to a gravitational field.)
- calculate the mass of earth by using law of gravitation.
- solve problems using Newton's law of gravitation.
- explain that value of 'g' decreases with altitude from the surface of earth.
- discuss the importance of Newton's law of gravitation in understanding the motion of satellites.

➤ Investigation Skills/ Laboratory work

The students will:

- determine the value of "g" using simple pendulum.

➤ Science, Technology and Society Connections

The students will:

- gather information to predict the value of the acceleration due to gravity 'g' at any planet or moon surface using Newton's law of gravitation.
- Describe how artificial satellites keep on moving around the earth due to gravitational force.

Conceptual linkage:

↓ This chapter is built on
Gravitation Science V
Earth & Space Science VI

↓ This chapter leads to
Gravitational Potential &
Escape Velocity Physics XI
Artificial satellites Physics XI

UNIT # 6

Work and Energy

Major Concepts (20 periods)

- Work
- Energy forms
- Kinetic energy and Potential energy
- Major sources of energy
- Efficiency
- Power

↓ Conceptual linkage:

This chapter is built on
Energy Science VI
Input, output & efficiency
Science VII

↓ This chapter leads to
Energy & Work Physics XI

➤ Learning Outcomes

Understanding

The students will:

- define work and its SI unit.
- calculate work done using equation
Work = force x distance moved in the direction of force
- define energy, kinetic energy and potential energy. State unit of energy.
- prove that Kinetic Energy $E_k = \frac{1}{2} mv^2$ and potential energy $E_p = mgh$ and solve problems using these equations.
- list the different forms of energy with examples.
- describe the processes by which energy is converted from one form to another with reference to
 - fossil fuel energy
 - hydroelectric generation
 - solar energy
 - nuclear energy
 - geothermal energy
 - wind energy
 - biomass energy
- state mass energy equation $E = mc^2$ and solve problems using it.
- describe the process of electricity generation by drawing a block diagram of the process from fossil fuel input to electricity output.
- list the environmental issues associated with power generation.
- differentiate energy sources as non renewable and renewable energy sources with examples of each.
- explain by drawing energy flow diagrams through steady state systems such as Filament lamp, a power station, a vehicle traveling at a constant speed on a level road.
- define efficiency of a working system and calculate the efficiency of an energy conversion using the formula
 - $\text{efficiency} = \frac{\text{energy converted into the required form}}{\text{total energy input}}$
- explain why a system cannot have an efficiency of 100%.
- define power and calculate power from the formula

- Power = work done / time taken
- define the unit of power “watt” in SI and its conversion with horse power.
- Solve problems using mathematical relations learnt in this unit.

Investigation Skills/ Laboratory work

The students will:

- investigate conservation of energy of a ball rolling down an inclined plane using double inclined plane and construct a hypothesis to explain the observation.
- compare personal power developed for running up stairs versus walking up stairs using a stopwatch.

Science, Technology and Society Connections

The students will:

- analyse using their or given criteria, the economic , social and environmental impact of various energy sources.[e.g. (fossil fuel, wind, falling water, solar, biomass, nuclear, thermal energy and its transfer(heat))].
- analyse and explain improvements in sports performance using principles and concepts related to work, kinetic and potential energy and law of conservation of energy (e.g. explain the importance of the initial kinetic energy of a pole vaulter or high jumper).
- search library or internet and compare the efficiencies of energy conversion devices by comparing energy input and useful energy output.
- explain principle of conservation of energy and apply this principle to explain the conversion of energy from one form to the other such as a motor, a dynamo, a photo cell and a battery, a freely falling body.
- list the efficient use of energy in the context of the home, heating and cooling of buildings and transportation.

UNIT # 7

Properties of Matter

Major Concepts (23 periods)

- Kinetic molecular model of matter
- Density
- Pressure,
- Atmosphere pressure
- Pressure in liquids
- Up thrust
- Principle of floatation
- Elasticity
- Stress, strain and Young's modulus

↴ Conceptual linkage:

This chapter is built on
Matter and its States
Science V

↴ This chapter leads to
Fluid Dynamics Physics XI
Physics of Solids XII

↴ Learning Outcomes

Understanding

The students will:

- state kinetic molecular model of matter (solid, liquid and gas forms).
- describe briefly the fourth state of matter i.e. "Plasma".
- define the term 'Density'
- compare the densities of a few solids, liquids and gases.
- define the term pressure (as a force acting normally on unit area).
- explain how pressure varies with force and area in the context of everyday examples.
- explain that the atmosphere exerts a pressure.
- describe how the height of a liquid column may be used to measure the atmospheric pressure.
- describe that atmospheric pressure decreases with the increase in height above the Earth's surface.
- explain that changes in atmospheric pressure in a region may indicate a change in the weather.
- state Pascal's law.
- apply and demonstrate the use with examples of Pascal's law
- state relation for pressure beneath a liquid surface to depth and to density i.e., ($p = \rho gh$) and solve problems using this equation.
- state Archimedes principle.
- determine the density of an object using Archimedes principle.
- state the upthrust exerted by a liquid on a body.
- state principle of floatation.
- explain that a force may produce a change in size and shape of a body.
- define the terms Stress, Strain and Young's modulus.
- state Hooke's law and explain elastic limit.

➤ Investigation Skills/ Laboratory work

The students will:

- measure the atmospheric pressure by Fortin's barometer.
- measure the pressure of motor bike / car tyre and state the basic principle of the instrument and its value in SI units.
- determine the density of irregular shaped objects.
- determine the density of a solid and of a liquid using Archimedes principle.
- determine the density of a liquid using 5 ml syringe.
- investigate the relationship between applied force and extension using Helical spring by plotting a graph and determine the value of spring constant.

➤ Science, Technology and Society Connection

The students will:

- explain that to fix a thumb pin, pressure exerted on the top increases thousands times on the pin point.
- explain the use of Hydrometer to measure the density of a car battery acid.
- explain that ships and submarines float on sea surface when the buoyant force acting on them is greater than their total weight.
- state that Hydraulic Press, Hydraulic car lift and Hydraulic brakes operate on the principle that the fluid pressure is transmitted equally in all direction.
- explain that the action of sucking through a straw, dropper, syringe and vacuum cleaner is due to atmospheric pressure.

Section 2 Heat

Overview: This section introduces the concept of internal energy and energy transfer processes related to heat. Students should possess experimental Investigation Skills/ Laboratory work in temperature and energy measurement. The precautions essential for accurate measurements in heat experiments should be understood in terms of the concepts learnt in this section. Students should be expected to suggest methods for improving the accuracy of these experiments.

UNIT # 8

Thermal Properties of Matter

Major Concepts (22 periods)

- Temperature and heat
- Thermometer
- Specific heat capacity
- Latent heat of fusion
- Latent heat of vaporization
- Evaporation
- Thermal Expansion

Conceptual linkage:

↓ This chapter is built on
Temperature Scales
Science IV
Thermal expansion Science VIII
Evaporization Science V

↓ This chapter leads to:
Thermodynamics Physics XI

Learning Outcomes

Understanding

The students will:

- define temperature (as quantity which determine the direction of flow of thermal energy).
- define heat (as the energy transferred resulting from the temperature difference between two objects).
- list basic thermometric properties for a material to construct a thermometer.
- convert the temperature from one scale to another (Fahrenheit, Celsius and Kelvin scales).
- describe rise in temperature of a body in term of an increase in its internal energy.
- define the terms heat capacity and specific heat capacity.
- describe heat of fusion and heat of vaporization (as energy transfer without a change of temperature for change of state).
- describe experiments to determine heat of fusion and heat of vaporization of ice and water respectively by sketching temperature-time graph on heating ice.
- explain the process of evaporation and the difference between boiling and evaporation.
- explain that evaporation causes cooling.
- list the factors which influence surface evaporation.
- describe qualitatively the thermal expansion of solids (linear and volumetric expansion).
- explain the thermal expansion of liquids (real and apparent expansion).

- solve numerical problems based on the mathematical relations learnt in this unit.

Investigation Skills/ Laboratory work

The students will:

- determine the melting point of ice by drawing temperature-time graph on heating
- determine the boiling point of water by drawing temperature-time graph on heating.
- measure the specific heat of a solid substance by method of mixture using polystyrene cup as calorimeter.
- determine the specific heat of fusion of ice.
- demonstrate that evaporation causes cooling.

Science, Technology and Society Connections

The students will:

- explain that the bimetallic strip used in thermostat is based on different rate of expansion of different metals on heating.
- describe one everyday effect due to relatively large specific heat of water.
- list and explain some of the everyday applications and consequences of thermal expansion.
- describe the use of cooling caused by evaporation in refrigeration process without using harmful CFC.

UNIT # 9

Transfer of Heat

Major Concepts (18 periods)

- The three process of heat transfer
- Conduction
- Convection
- Radiation
- Consequences and everyday application of heat transfer

↴ Conceptual linkage:

This chapter is built on
Modes of heat transfer
Science VII

↴ This chapter leads to
Thermodynamics physics XI

➤ Learning Outcomes

Understanding

The students will:

- recall that thermal energy is transferred from a region of higher temperature to a region of lower temperature.
- describe in terms of molecules and electrons , how heat transfer occurs in solids.
- state the factors affecting the transfer of heat through solid conductors and hence, define the term “Thermal Conductivity”.
- solve problems based on thermal conductivity of solid conductors.
- write examples of good and bad conductors of heat and describe their uses.
- explain the convection currents in fluids due to difference in density.
- state some examples of heat transfer by convection in everyday life.
- explain insulation reduces energy transfer by conduction.
- describe the process of radiation from all objects.
- explain that energy transfer of a body by radiation does not require a material medium and rate of energy transfer is affected by:
 - Colour and texture of the surface
 - Surface temperature
 - Surface area

➤ Investigation Skills/ Laboratory work

The students will:

- describe convection in water heating by putting a few pinky crystals in a round bottom flask.
- explain that water is a poor conductor of heat.
- investigate the absorption of radiation by a black surface and silvery surfaces using Leslie cube.
- investigate the emission of radiation by a black surface and silvery surfaces using Leslie cube.

➤ Science, Technology and Society Connection

The students will:

- describe the use of cooking utensils, electric kettle, air conditioner, refrigerator cavity wall insulation, vacuum flask and household hot-water system as a consequence of heat transmission processes.
- explain convection in seawater to support marine life.
- describe the role of land breeze and sea breeze for moderate coastal climate.
- describe the role of convection in space heating.
- Identify and explain some of the everyday applications and consequences of heat transfer by conduction, convection and radiation.
- explain how the birds are able to fly for hours without flapping their wings and glider is able to rise by riding on thermal currents which are streams of hot air rising in the sky.
- explain the consequence of heat radiation in greenhouse effect and its effect in global warming.

Section 3 Oscillations and Waves

Overview: This section examines the basic nature and properties of waves. Light and sound waves, in particular, are studied in detail. Students should possess practical Investigation Skills/ Laboratory work in the study of vibrations and waves through various physical models. They need to develop the Investigation Skills/ Laboratory work for interpreting indirect measurements and demonstrations of wave motions. They should be aware that various models are used in the study of waves, e.g. the ray model is used in geometrical optics for image formation and the wave model is used to explain the phenomena such as diffraction and interference.

UNIT # 10 Simple Harmonic Motion and Waves

Major Concepts (18 periods)

- Simple Harmonic Motion (SHM)
- Motion of mass attached to a spring
- Simple pendulum
- Waves, their nature and type
- Properties of waves

Conceptual linkage:

- ↓ This chapter is built on
Waves & Sound Science VII
- ↓ This chapter leads to
Oscillation Physics XI
Waves Physics XI

Learning Outcomes

Understanding

The students will:

- state the conditions necessary for an object to oscillate with SHM.
- explain SHM with simple pendulum, ball and bowl examples.
- draw forces acting on a displaced pendulum.
- solve problems by using the formula $T = 2\pi \sqrt{l/g}$ for simple pendulum
- understand that damping progressively reduces the amplitude of oscillation.
- describe wave motion as illustrated by vibrations in rope, slinky spring and by experiments with water waves.
- describe that waves are means of energy transfer without transfer of matter.
- distinguish between mechanical and electromagnetic waves.
- identify transverse and longitudinal waves in mechanical media, slinky and springs.
- define the terms speed (v), frequency (f), wavelength (λ), time period (T), amplitude, crest, trough, cycle, wave front, compression and rarefaction.
- derive equation $v = f \lambda$.
- solve problems by applying the relation $f = 1/T$ and $v = f \lambda$.
- describe properties of waves such as reflection, refraction and diffraction with the help of ripple tank.

➤ Investigation Skills/ Laboratory Work

The students will:

- construct a transverse wave model
- construct a longitudinal wave model by hanging a weight with a spring
- prove that time period is independent of
 - i. mass of the pendulum
 - ii. amplitude of the pendulum
- analyze information from the given displacement-time graph for transverse wave motion.
- Find the value of 'g' using simple pendulum.

➤ Science, Technology and Society Connections

The students will:

- explain the diffraction of radiowaves but not of T.V waves (transmission can be heard in such areas where the waves cannot reach directly).

UNIT # 11

Sound

Major Concepts (18 periods)

- Sound waves
- Speed of sound
- Characteristics of sound
- Noise pollution
- Audible frequency range
- Ultrasound

➤ Learning outcomes

Understanding

The students will:

- explain how sound is produced by vibrating sources and that sound waves require a material medium for their propagation.
- describe the longitudinal nature of sound waves (as a series of compressions and rarefactions).
- define the terms pitch, loudness and quality of sound.
- describe the effect of change in amplitude on loudness and the effect of change in frequency on pitch of sound.
- define intensity and state its SI unit.
- describe what is meant by intensity level and give its unit.
- explain that noise is a nuisance.
- describe how reflection of sound may produce echo.
- describe audible frequency range.
- describe the importance of acoustic protection.
- solve problem based on mathematical relations learnt in this unit.

➤ Investigation Skills/ Laboratory work

The students will:

- identify sources of noise in their environment and suggest how such noise can be reduced to an acceptable level.
- estimate the speed of sound in air by echo method.

➤ Science, Technology and Society Connections

The students will:

- describe that some sounds are injurious to health.
- describe how knowledge of the properties of sound waves is applied in the design of buildings with respect to acoustics.
- describe how ultrasound techniques are used in medical and industry.
- explain the use of soft materials to reduce echo sounding in classroom studies, and other public gathering buildings.

Conceptual linkage:

↓ This chapter is built on

Sound Science VI

Sound Science VII

Logarithm Maths IX

↓ This chapter leads to

Sound Waves and related

phenomena Physics XI

UNIT # 12

Geometrical Optics

Major Concepts (23 periods)

- Reflection of light
- Image location by spherical mirror equation
- Refraction of light
- Total internal reflection
- Refraction through a prism
- Image location by lens equation
- Magnifying power and resolving power
- Compound microscope
- Telescope
- Defects in vision

Conceptual linkage:

↴ This chapter is built on
Spherical Mirrors Science VI
Light (Dispersion) science VII
Lenses Science VIII

↴ This chapter leads to
Electron Microscope

➤ Learning outcomes

Understanding

The students will:

- describe the terms used in reflection including normal, angle of incidence, angle of reflection and state laws of reflection..
- solve problems of image location by spherical mirrors by using mirror formula.
- define the terminology for the angle of incidence i and angle of refraction r and describe the passage of light through parallel-sided transparent material.
- solve problems by using the equation $\sin i / \sin r = n$ (refractive index).
- state the conditions for total internal reflection.
- describe the passage of light through a glass prism.
- describe how total internal reflection is used in light propagation through optical fibres.
- describe how light is refracted through lenses.
- define power of a lens and its unit.
- solve problems of image location by lenses using lens formula.
- define the terms resolving power and magnifying power.
- draw ray diagram of simple microscope and mention its magnifying power.
- draw ray diagram of compound microscope and mention its magnifying power.
- draw ray diagram of a telescope and mention its magnifying power
- draw ray diagrams to show the formation of images in the normal eye, a short-sighted eye and a long-sighted eye.
- describe the correction of short-sight and long-sight.

➤ Investigation Skills/ Laboratory work

The students will:

- perform a first-hand investigation to calculate the refractive index of glass or Perspex.
- plan and perform to find the refractive index of water using a concave mirror.
- plan and investigate the formation of images by a concave mirror.

- plan and investigate the formation of images by a convex lens.
- determine the focal length of a convex lens by parallax method.
- set up a microscope and a telescope.
- plan and determine critical angle using a semicircular glass slab or by a prism.
- trace the path of a ray of light through a glass prism and measure the angle of deviation.

➤Science, Technology and Society Connections

The students will:

- describe the use of spherical mirrors for safe driving, blind turns on hilly roads, dentist mirror.
- describe the use of optical fibres in telecommunications and medical field and state the advantages of their use.
- describe the use of a single lens as a magnifying glass and in a camera, projector and photographic enlarger and draw ray diagrams to show how each forms an image.
- describe the use of lenses/ contact lenses for rectifying vision defects of the human eye.
- describe the exploration of the world of micro organism by using microscopes and of distant celestial bodies by telescopes.

Section 4 Electricity & Magnetism

Overview: This section examines basic knowledge of electricity and magnetism. Students should possess practical Investigation Skills/ Laboratory work in circuit connections. They should be able to perform electrical measurements using various equipments such as ammeters, voltmeters, galvanometers and multi-meters. As electricity became increasingly used as the main power supply in homes and electrical appliances became an integral part of daily life, the dangers associated with electricity became more prominent. Safety devices in household appliances and within the electric circuits in the home can prevent electrical injury or assist in reducing the potential for electric shock. Introduction to basic operations of digital electronics, information and communication technology has been included for an appreciation of outcomes of the principles of physics in everyday life. Students are expected to possess Investigation Skills/ Laboratory work of conducting experiments to study, demonstrate and explore concepts such as electric fields, magnetic fields, and electromagnetic induction. Students should gain practical experience related to design processes through the construction of physical models such as motors and generators. This section increases student understanding of nature and practice of physics and its applications and uses.

Unit – 13

Electrostatics

Major Concepts (20 periods)

- Electric charge
- Electrostatic induction
- Electroscope
- Coulomb's law
- Electric field and its intensity
- Electrostatic potential
- Applications of electrostatic
- Capacitors and capacitance
- Different types of capacitors

Conceptual linkage:

↓ This chapter is built on
Charges Science IV-V
Electric Potential
Science VII

↓ This chapter leads to
Electrostatics Physics XII

Learning Outcomes

Understanding

The students will:

- describe simple experiments to show the production and detection of electric charge.
- describe experiments to show electrostatic charging by induction.
- state that there are positive and negative charges.
- describe the construction and working principle of electroscope.
- state and explain Coulomb's law.
- solve problems on electrostatic charges by using Coulomb's law.

- define electric field and electric field intensity.
- sketch the electric field lines for an isolated +ve and –ve point charges.
- describe the concept of electrostatic potential.
- define the unit “volt”.
- describe potential difference as energy transfer per unit charge.
- describe one situation in which static electricity is dangerous and the precautions taken to ensure that static electricity is discharged safely.
- describe that the capacitor is charge storing device.
- define capacitance and its unit.
- derive the formula for the effective capacitance of a number of capacitors connected in series and in parallel.
- apply the formula for the effective capacitance of a number of capacitors connected in series and in parallel to solve related problems.

➤ Investigation Skills/ Laboratory work

The students will:

- demonstrate the existence of different kind of charges.
- demonstrate that like charges repel each other and unlike charges attract each other using an electroscope.
- detect the type of charge on a body using an electroscope.

➤ Science, Technology and Society Connections

The students will:

- describe the use of electrostatic charging (e.g. spraying of paint and dust extraction).
- list the use of capacitors in various electrical appliances.

UNIT # 14

Current Electricity

Major Concepts (23 periods)

- Electric current
- Potential difference and emf
- Ohm's law
- Resistance, series and parallel combinations
- The I-V characteristics for ohmic and non ohmic conductors
- Electrical power and Joule's law
- Use of circuit components
- Measuring instruments (voltmeter, galvanometer, ammeter)
- Alternating current A.C
- Safety measures

Conceptual linkage:

- ↓ This chapter is built on Electricity and magnetism Science VII
- ↓ This chapter leads to Current Electricity Physics XII

Learning Outcomes

Understanding

The students will:

- define electric current.
- describe the concept of conventional current.
- understand the potential difference across a circuit component and name its unit .
- describe Ohm's law and its limitations.
- define resistance and its unit(Ω).
- calculate the effective resistance of a number of resistances connected in series and also in parallel.
- describe the factors affecting the resistances of a metallic conductor.
- distinguish between conductors and insulators.
- sketch and interpret the V-I characteristics graph for a metallic conductor, a filament lamp and a thermistor.
- describe how energy is dissipated in a resistance and explain Joule's law.
- apply the equation $E = I.Vt = I^2Rt = V^2 t/R$ to solve numerical problem.
- calculate the cost of energy when given the cost per kWh.
- distinguish between D.C and A.C.
- identify circuit components such as switches, resistors, batteries etc.
- describe the use of electrical measuring devices like galvanometer, ammeter and voltmeter (construction and working principles not required).
- construct simple series (single path) and parallel circuits (multiple paths).
- predict the behaviour of light bulbs in series and parallel circuit such as for celebration lights.
- state the functions of the live, neutral and earth wires in the domestic main supply.

- state reason why domestic supplies are connected in parallel.
- describe hazards of electricity (damage insulation, overheating of cables, damp conditions).
- explain the use of safety measures in household electricity, (fuse, circuit breaker, earth wire).

Investigation Skills/ Laboratory work

The students will:

- measure the electric current through a bulb using battery or cell in a given circuit with the help of an ammeter.
- measure the potential difference across a (i) bulb (ii) battery or cell in a given circuit using voltmeter.
- investigate that voltage across all the components remains same in parallel circuit.
- verify ohms law by devising an experiment.
- determine the resistance of a resistor using a voltmeter and an ammeter.
- plan, choose equipments or resources and perform a first hand investigation to construct a model household circuit using electrical components.
- determine the resistance of a galvanometer by half deflection method.

Science, Technology, and Society Connections.

The students will:

- write a paragraph by realizing that it is difficult to imagine what life would be like without electricity.
- Identify ways to reduce electricity consumption in everyday life.
- calculate the total cost of electrical energy used in one month (30 day) at home. Suggest ways how it can be reduced without compromising the comforts and benefits of electricity.
- describe the damages of an electric shock from appliances on the human body.
- explain the underlying principles in the working of volume controls of radio and T.V.
- identify the use of fuses, circuit breakers, earthing, double insulation and other safety measures in relation to household electricity.

UNIT # 15

Electromagnetism

Major Concepts (23 periods)

- Magnetic effect of a steady current
- Force on a current carrying conductor in a magnetic field
- Turning effect on a current carrying coil in a magnetic field
- D.C motor
- Electromagnetic induction
- A.C generator
- Mutual Induction
- Transformer

Conceptual linkage:

- ↳ This chapter is built on Electricity & Magnetism Science VIII
- ↳ This chapter leads to Electro magnetism Physics XII
Electromagnetic Induction
Physics XII

➤ Learning Outcomes

Understanding

The students will:

- explain by describing an experiment that an electric current in a conductor produces a magnetic field around it.
- describe that a force acts on a current carrying conductor placed in a magnetic field as long as the conductor is not parallel to the magnetic field.
- state that a current carrying coil in a magnetic field experiences a torque.
- relate the turning effect on a coil to the action of a D.C. motor.
- describe an experiment to show that a changing magnetic field can induce e.m.f. in a circuit.
- list factors affecting the magnitude of an induced e.m.f.
- explain that the direction of an induced e.m.f opposes the change causing it and relate this phenomenon to conservation of energy .
- describe a simple form of A.C generator.
- describe mutual induction and state its units.
- describe the purpose of transformers in A.C circuits.
- identify that a transformer works on the principle of mutual induction between two coils.

➤ Investigation Skills/ Laboratory work

The students will:

- conduct an experiment to identify the pattern of magnetic field of (i) bar magnet (ii) circular coil carrying current , using iron filings (ii) magnetic compass
- Investigate to generate electric current by moving a magnet in a coil or a coil near a magnet.

- investigate to identify the factors that affect the magnitude and direction of the electric current induced by a changing magnetic field.

➤Science, Technology and Society Connection

The students will:

- describe the application of the magnetic effect of an electric current in relay, door latch, loudspeaker, and circuit breaker.
- analyze and describe the operation of industrial and domestic technological system based on principles related to magnetic field (e.g. electric motors, electric generators, components in home entertainment system, computers, doorbells, telephones, credit card).
- describe the historical development of technologies related to magnetic fields (e.g. electric motors and generators, medical equipment, loudspeakers, magnetic information storage devices (Audio-Video cassettes).
- identify the role of transformers in power transmission from power station to your house.
- list the use of transformer (step – up and step-down) for various purposes in your home.
- discuss and list the advantage of high voltage power transmission.

UNIT # 16

Introductory Electronics

Major Concepts (23 periods)

- Thermionic emission
- Electron gun and cathode rays
- Deflection of electron by electric field
- Deflection of electron by magnetic field
- Cathode rays oscilloscope (CRO)
- Introduction to electronics
- Analogue and digital electronics
- Logic gates

Conceptual linkage:

↓ This chapter is built on
Electricity Science VIII
Binary numbers
Maths class VII

↓ This chapter leads to
Electronics Physics XII

Learning Outcomes

Understanding

The students will:

- explain the process of thermionic emission emitted from a filament.
- describe the simple construction and use of an electron gun as a source of electron beam.
- describe the effect of electric field on an electron beam.
- describe the effect of magnetic field on an electron beam.
- describe the basic principle of CRO and make a list of its uses.
- differentiate between analogue and digital electronics.
- state the basic operations of digital electronics.
- identify and draw the symbols for the logic gates (NOT, OR, AND, NOR and NAND).
- state the action of the logic gates in truth table form.
- describe the simple uses of logic gates.

Investigation Skills/ Laboratory work

The students will:

- identify & draw representative diagrams for various logic gates.
- verify truth tables of NOT, OR, AND, NOR and NAND gates.
- make burglar alarm/ fire alarm using an appropriate gate.

Science, Technology and Society Connections

The students will:

- compare an analogue wrist watch with a digital wrist watch with reference to energy conversions and time display on dials.
- identify the use of logic gates for security purposes (e.g; burglar alarm, fire-extinguisher etc.).
- identify by quoting examples that the modern world is the world of digital electronics.
- identify that the computers are the forefront of electronic technology.
- realize that electronics is shifting from low-tech electrical appliances to high-tech electronic appliances.

UNIT # 17

Information and Communication Technology

Major Concepts (16 periods)

- Components of ICT
- Flow of information
- Communication technology
- Storing information
- Handling information

Conceptual linkage:

- ↓ This chapter is built on
Information handling Maths IX-X
- ↓ This chapter leads to
Role of E.M. waves in
communication technology
Physics XII

Learning Outcomes

Understanding

The students will:

- describe the components of information technology.
- explain briefly the transmission of
 1. electric signals through wires
 2. radiowaves through air
 3. light signals through optical fibres
- describe function and use of fax machine, cell phone, photo phone and computer.
- make a list of the use of E-mail and internet.
- describe the use of information storage devices such as audio cassettes, video cassettes, hard discs, floppy, compact discs and flash drive.
- identify the functions of word processing, data managing, monitoring and controlling.

Investigation Skills/ Laboratory work

The students will:

- analyse and describe the energy transformations that occur in cell phone photo phone and fax machine.
- identify various components of ICT.
- design and construct a simple communication system (intercom).
- identify various information storage devices and compare their advantages.
- use E-mail and explore internet to search the latest information and communication devices.

Science, Technology and Society Connections

The students will:

- compare the advantages of high-tech. communication devices with the traditional system through library or internet search.
- assess the risks and benefits to society and the environment of introducing ICT (e.g. effects on personal privacy, criminal activities, health and transfer of information).
- make a list of the use of computer technology in various fields of daily life.

Section 5 Atomic and Nuclear Physics

Overview: In this section, the radioactivity is introduced. Students are expected to become aware of the existence of radiation emitting materials and also background radiation and its sources. Students should possess the analytic Investigation Skills/ Laboratory work to draw valid conclusions from the study involving radioactivity. They should be aware of the potential danger of radioactive sources and the application of radioactivity in different disciplines. Students should be able to evaluate scientific information and appreciate the importance of making informed decision when facing issues such as the debate on the use of nuclear energy.

UNIT # 18

Radioactivity

Major Concepts (16 periods)

- Atom and Atomic nucleus
- Natural radioactivity
- Natural transmutations
- Background radiation
- Half life
- Radio isotopes
- Fission and fusion
- Hazards and safety measures

Conceptual linkage:

- ↓ This chapter is built on Structure of Atom Science VII
Atomic Structure Chemistry IX
- ↓ This chapter leads to Nuclear Physics XII

Learning outcomes

Understanding

The students will:

- describe the structure of an atom in terms of a nucleus and electrons.
- describe the composition of the nucleus in terms of protons and neutrons.
- explain that number of protons in a nucleus distinguishes one element from the other.
- represent various nuclides by using the symbol of proton number Z , nucleon number A and the nuclide notation ${}_Z^AX$.
- explain that some nuclei are unstable, give out radiation to get rid of excess energy and are said to be radioactive.
- describe that the three types of radiation are α , β & γ .
- state, for radioactive emissions:
 - their nature
 - their relative ionizing effects.
 - their relative penetrating abilities.
- explain that an element may change into another element when radioactivity occurs.

- represent changes in the composition of the nucleus by symbolic equations when alpha or beta particles are emitted.
- describe that radioactive emissions occur randomly over space and time.
- explain the meaning of half life of a radioactive material.
- describe what are radio isotopes. What makes them useful for various applications?.
- describe briefly the processes of fission and fusion.
- show an awareness of the existence of background radiation and its sources.
- describe the process of carbon dating to estimate the age of ancient objects.
- describe hazards of radioactive materials.

➤Investigation Skills/ Laboratory work

The students will:

- make calculations based on half-life which might involve information in tables or shown by decay curves.
- determine the half-life of a sample of radioactive material by using a graph of number of radioactive nuclei or activity versus time.

➤Science, Technology and Society Connections

The students will:

- describe how radioactive materials are handled, used, stored and disposed of, in a safe way.
- make a list of some applications of radioisotopes in medical, agriculture and industrial fields.
- make estimation of age of ancient objects by the process of carbon dating.

LIST OF PRACTICAL FOR IX-X GRADES

Standard experiments

- 1 To measure the area of cross section by measuring diameter of a solid cylinder with vernier callipers.
- 2 To measure the volume of a solid cylinder by measuring length and diameter of a solid cylinder with vernier callipers.
- 3 To measure the thickness of a metal strip or a wire by using a screw gauge.
- 4 To find the acceleration of a ball rolling down an angle iron by drawing a graph between $2S$ and T^2 .
- 5 To find the value of “g” by free fall method.
- 6 Investigate the relationship between force of limiting friction and normal reaction to find the co-efficient of sliding friction between a wooden block and horizontal surface.
- 7 Measure the force of limiting friction by rolling a roller on a horizontal plane.
- 8 To determine the value of “g” by the Atwood’s machine.
- 9 To determine the resultant of two forces graphically using a Horizontal force table.
- 10 To verify the principle of moments by using a metre rod balanced on a wedge.
- 11 To find the tension in the strings by balancing a metre rod on the stands.
- 12 To find the weight of an unknown object by using vector addition of forces.
- 13 To find the weight of an unknown object by using principle of moments.
- 14 To study the effect of the length of simple pendulum on time and hence find “g” by calculation.
- 15 To prove that time period of a simple pendulum is independent of (i) mass of the pendulum (ii) amplitude of the vibration.
- 16 To study the relationship between load and extension (Helical spring) by drawing a graph.
- 17 To find the density of a body heavier than water by Archimedes principle.

- 18 To find the density of a liquid using 5 ml syringe (instead of density bottle).
- 19 To find the specific heat by the method of mixture using polystyrene cups (used as container of negligible heat capacity).
- 20 To draw a graph between temperature and time when ice is converted into water and then to steam by slow heating.
- 21 To measure the specific heat of fusion of ice.
- 22 To verify the laws of refraction by using a glass slab.
- 23 To find the refractive index of water by using concave mirror.
- 24 To determine the critical angle of glass using a semi circular slab and a light ray box/or by prism.
- 25 To trace the path of a ray of light through glass prism and measure the angle of deviation.
- 26 To find the focal length of a convex lens by parallax method.
- 27 To set up a microscope and telescope.
- 28 Verify Ohm's law (using wire as conductor).
- 29 To study resistors in series circuit.
- 30 To study resistors in parallel circuit.
- 31 To find the resistance of galvanometer by half deflection method.
- 32 To trace the magnetic field using a bar magnet.
- 33 To trace the magnetic field due to a current carrying circular coil.
- 34 To verify the truth table of OR, AND, NOT, NOR and NAND gates.
- 35 To make a burglar alarm/fire alarm using an appropriate gate.

Note:

1. At least 30 standard practical alongwith exercises are required to be performed during the two years of course of studies of grades IX-X.
2. Use of centimetre graph paper be made compulsory.

LIST OF APPARATUS / EQUIPMENTS REQUIRED ACCORDING TO THE PHYSICS EXPERIMENTS FOR IX-X GRADES

Experiment Apparatus /Equipment No.

1. Vernier callipers, solid cylinder.
2. Vernier callipers, solid cylinder.
3. Screw gauge, metal strip or small solid sphere or a piece of wire.
4. Angle iron 2m long, 2 wooden stands having V-shaped top, steel ball, stopwatch, metre rod.
5. Free-fall apparatus, a metal bob, stopwatch.
6. Horizontal plane, weight box, pulley, wooden block, pan, thread, spring balance, metre rod.
7. Horizontal plane, weight box, pulley, pan, thread, ruler.
8. Atwood's machine, stopwatch, metre rod.
9. Horizontal board fixed with three pulleys, plane mirror strip, 3 sets of slotted masses of 50 g with hangers, thread, metre scale, protractor.
10. Metre rod, wooden wedge, thread, weight box.
11. Two stands, two spring balances, metre rod, thread.
12. Horizontal board fixed with three pulleys, plane mirror strip, 3 sets of slotted masses of 50 g with hangers, thread, metre scale, protractor.
13. Wedge, metre rod, slotted weights, thread, object of unknown weight.
14. Metallic bob, vernier callipers, metre scale, stopwatch, splitted cork, stand with clamp.
15. Metallic bob, vernier callipers, metre scale, stopwatch, splitted cork, stand with clamp.
16. Helical spring, iron stand, half metre rod, set of masses with hanger.
17. Physical balance, weight box, solid body (glass stopper), beaker, thread, small wooden bench, water, thermometer.
18. 5 ml disposable syringe, liquid, water, beaker, weight box, physical balance.
19. Polystyrene cup, two thermometers, heating arrangement, metallic bob, physical balance, weight box.
20. Gas burner or spirit lamp, thermometer (-10°C to 110°C), iron stand, beaker, stopwatch, tripod stand, stirrer.
21. Copper calorimeter with lagging, thermometer, ice chips.

22. Rectangular glass slab, common pins, drawing pins, drawing board, geometry box, white sheet of paper.
23. Concave mirror, stand with a clamp, cork with a pin.
24. Semi circular glass block, ray box, drawing board, white paper and pins, protractor, half metre rule, pair of compasses or prism.
25. Glass prism, drawing board, white paper and drawing pins, common pins, geometry box.
26. Convex lens, two needles, three uprights, knitting needle and a metre rod.
27. Convex lens of different focal length and metre rod.
28. Voltmeter, ammeter, a piece of resistance wire, rheostat, battery, connecting wires, key.
29. Two standard resistances, voltmeter, ammeter, connecting wires, key, battery, rheostat.
30. Two standard resistances, voltmeter, ammeter, connecting wires, key, battery, rheostat.
31. Galvanometer, dry cell with box, high resistance box, low resistance box, two keys.
32. Bar magnet, drawing board, white paper and pins, magnetic compass, needle, pencil.
33. Circular coil fitted on a wooden board, compass needle, ammeter, battery, key.
34. OR gate, AND gate, NOT gate, NOR gate and NAND gate modules, power supply, LED indicator module.
35. NOT gate module, thermistor or smoke sensor, alarm system, power pack.

**COMPREHENSIVE LIST OF REQUIRED APPARATUS FOR A
STANDARD PHYSICS LABORATORY FOR GRADES IX-X
(FOR A GROUP OF 40 STUDENTS)**

Sr. No.	Apparatus/ Equipment	Quantity
1.	Vernier Callipers	12
2.	Screw gauge	12
3.	Solid cylinder	12
4.	Metallic wire	1 kg
5.	Small metallic sphere	12
6.	Angle iron 2m long with steel ball	10
7.	Wooden stands having V-shaped top	10
8.	Atwood's machine	10
9.	Stopwatch	10
10.	Free fall apparatus	10
11.	Metallic bob	10
12.	Wooden block	10
13.	Weight box with fractional weights	2
14.	Pulley	20
15.	Spring balance	20
16.	Horizontal Board fixed with three pulleys	10
17.	Pan	20
18.	Slotted weights with hangers set of 50g weights	20
19.	Slotted weights with hangers set of 20g weights	20
20.	Metre rod	20
21.	Wedge	12
22.	Plane mirror strip	24
23.	Protractor	24
24.	Inclined plane	10
25.	Steel roller with suspended pan	10
26.	Helical spring	24
27.	Iron stands with clamps	20

28.	Physical balance	02
29.	Beaker (Assorted 250 cc, 500 cc, 1000 cc)	24
30.	Small wooden bench	10
31.	5 ml disposable syringes	20
32.	Polystyrene cups	24
33.	Thermometer – 10°C to 110°C with half degree mark	24
34.	Gas burner or spirit lamp	10
35.	Solid lead shots	1 kg
36.	Tripod stand	10
37.	Stirrer	10
38.	Thread	5 spool
39.	Splitted cork	1 pkt
40.	Rubber pad	12
41.	Concave mirror with stand	12
42.	Needles with stands (Uprights)	24
43.	Kitting needle	12
44.	Rectangular glass slab	12
45.	Common pins	2 pkt
46.	Drawing board pins	2 pkt
47.	White paper	1 pkt
48.	Semi circular glass slab	10
49.	Light ray box	10
50.	Drawing board	15
51.	Compass	15
52.	Glass prism	12
53.	Convex lens ($f = 10\text{ cm}$ to 20 cm)	20
54.	Voltmeter (0 - 5V)	10
55.	Ammeter (0 – 3A)	10
56.	Resistance wire	1 spool
57.	Rheostat	10
58.	Connecting wires	2 kg

59.	Keys	20
60.	Standard resistances (1Ω , 2Ω , 5Ω , 10Ω)	10 each
61.	Galvanometer	10
62.	Dry cell with box	24
63.	High resistance box	12
64.	Low resistance box	12
65.	Bar magnet	12 set
66.	Circular coil (fitted on wooden board)	10
67.	Power supply	10
68.	OR gate module	10
69.	AND gate module	10
70.	NOR gate module	10
71.	NAND gate module	10
72.	NOT gate module	10
73.	LED indicator module	10
74.	Alarm system	5
75.	Smoke sensor	5
76.	Thermistor	5

Estimated Time Allocation and Weighting for Various Units/Chapters

GRADES IX-X (Two years course)

Unit #	Content	Weighting in %age	Periods (Theory)	Periods (Investigation / Practical work)
1.	Physical quantities and measurement	6%	13	8
2.	Kinematics	6%	13	6
3.	Dynamics	7%	15	6
4.	Turning effect of forces	6%	12	8
5.	Gravitation	5%	12	4
6.	Work & Energy	5%	14	6
7.	Properties of Matter	5%	15	8
8.	Thermal properties of matter	6%	14	8
9.	Transfer of thermal energy	4%	12	6
10.	SHM & waves	5%	12	6
11.	Sound	5%	12	6
12.	Geometrical optics	5%	15	8
13.	Electrostatics	6%	14	6
14.	Current electricity	7%	15	8
15.	Electromagnetism	7%	15	8
16.	Introductory electronics	5%	15	8
17.	Information & communication Technology	5%	10	6
18.	Radioactivity	5%	12	4
		100%	240	120

ASSESSMENT OBJECTIVES

The Investigation Skills/ Laboratory work appropriate to physics are broadly categorized as:

- a. **Knowledge with understanding and its applications.**
- b. **Handling information and problem solving.**
- c. **Experimental Investigation Skills/ Laboratory work and investigations.**

The objectives of the examination are to assess students abilities.

(a) **Knowledge, understanding and applications**

The student should be able to:

1. recall and understand the knowledge and principles of Physics set out in the syllabus.
2. demonstrate the understanding of scientific vocabulary, terminology and units.
3. apply the knowledge and principles of physics set out in the syllabus to explain simple phenomena or effects which are not already familiar to them.
4. understand the application of Physics with their social, economic and environmental implications.

(b) **Handling information and solving problems**

The students should be able to:

1. search, select, understand and interpret scientific information from a variety of sources, including everyday experience.
2. present and communicate scientific information in appropriate forms.
3. translate information from one form to another.
4. Draw graphs and interpret information from them.
5. manipulate numerical and other data.
6. apply the knowledge and principles of physics set out in the syllabus to solve problems involving familiar or unfamiliar situation.

Experimental Investigation Skills/ Laboratory work and investigation

The student should be able to:

1. understand the use of scientific instruments and apparatus, including techniques of operation, essential precautions and safety aspects.
2. make and record observations, measurements and estimates with due regard to precision, accuracy and units.
3. analyze and interpret information and result obtained in scientific investigation and practical work, identify patterns and trends, and draw valid conclusion.

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 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 IX-X (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 two year. The syllabus division is suggested as shown below:

Sections		Weighting
1. Mechanics	Chapter 1 to 7	40%
2. Heat	Chapter 8-9	10 %
3. Oscillations and Waves	Chapter 10-12	15 %
4. Electricity and Magnetism	Chapter 13-17	30 %
5. Atomic & Nuclear Physics	Chapter 18	5 %

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 under standing of the whole syllabus and should test the following range of abilities.

Knowledge and understanding (recall 30%)	60%
Higher abilities (handling information, Applications, and problem solving etc.)	40%

Paper - 1 (Part-I) Half an hour 20%	20 compulsory objective questions. This may include MCQ of various types to evaluate abilities and Investigation Skills as detailed in Assessment objectives (a) and (b).
Paper - 1 (Part-II) 2 2½ hour Section-I 40% Section-II 25%	This paper should consists of two sections. Section I should contain ten to fifteen compulsory short questions/constructed response questions to provide 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 which may include choice of attempting 2 questions. Any calculations required should be simple and direct.

Paper-II Practical Test (2 hours) 15%	One practical exercise from a choice of two alternatives based to test the experimental and Investigation Skills/ Laboratory work given in Assessment objectives (C).
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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 Investigation 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 Investigation Skills included in the syllabus to solve the problems.
- (iv) In general, SI units and terminology will be used.
- (v) It is suggested that in addition to external examination, the teacher should evaluate class work on completion of each lesson/unit. Four more internal school examinations during the course 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.
3. 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 everyday 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 labeled 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.

CONCEPT MAPPING

A particularly good way to organize information about a problem or subject is to construct a "concept map." Construction of concept maps helps us pull together information we already know about a subject and understand new information as we learn. It is a versatile tool for assisting and enhancing many of the types of thinking and learning that we are required to do.

Concept mapping helps students fulfill high-quality and meaningful learning outcomes in science. Maps provide concrete visual aids to help organize information before it is learned. Students can make their own maps while they learn, and examine the changes in their thinking as they construct their understanding. Maps can also be made as a type of assessment at the conclusion of lessons.

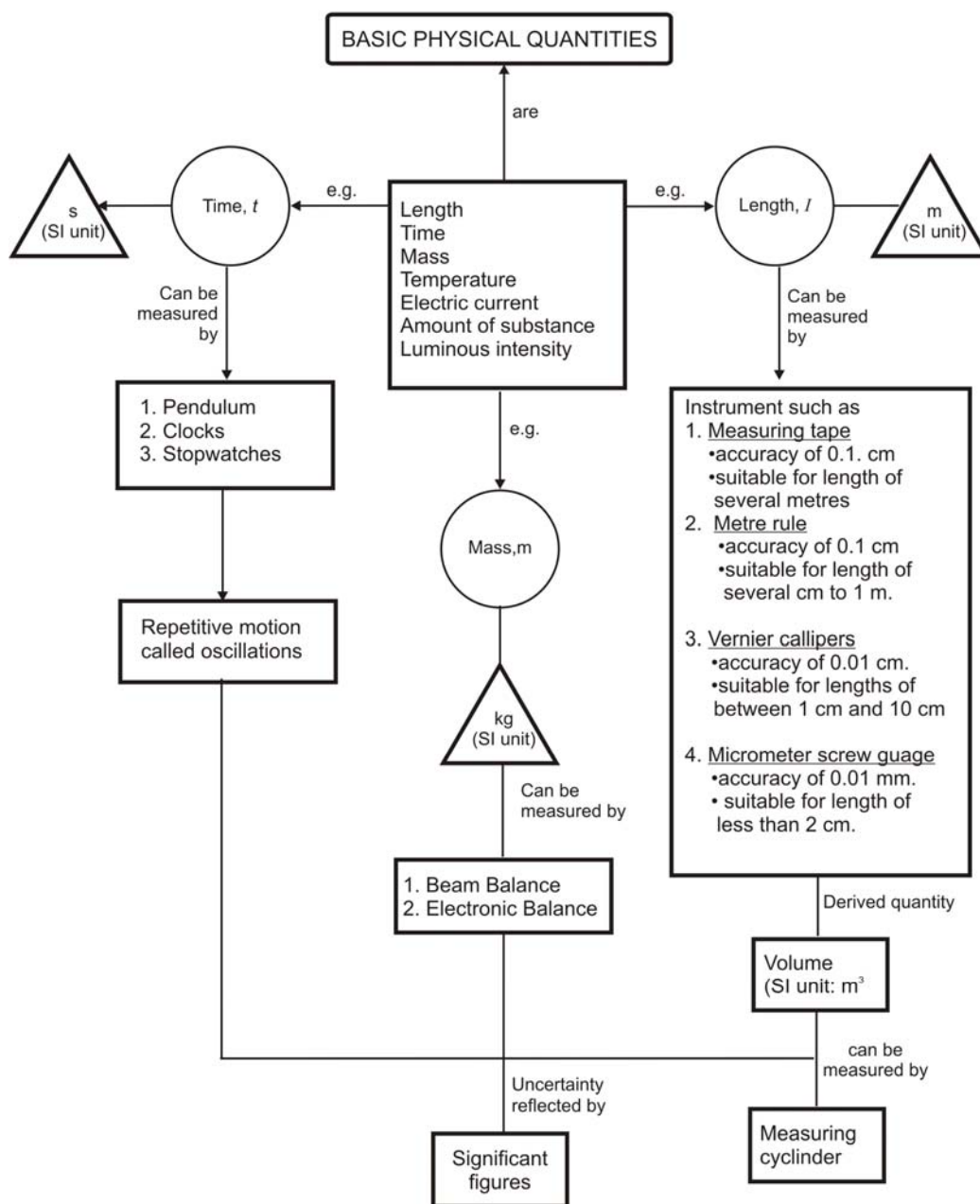
Concept maps show a definite relationship between big ideas and small ideas, thus clarifying the difference between details or specifics and the big idea or subordinate concept. This can be helpful when a teacher must decide how much emphasis to give to specific facts as compared to concepts in a lesson.

The concept maps also provide visual imagery that can help students recall information and see relationships between concepts. Concept maps show hierarchies of ideas that suggest psychologically valid sequences. These hierarchies may not match the linear sequence, or outline, that a teacher has decided to use for a presentation.

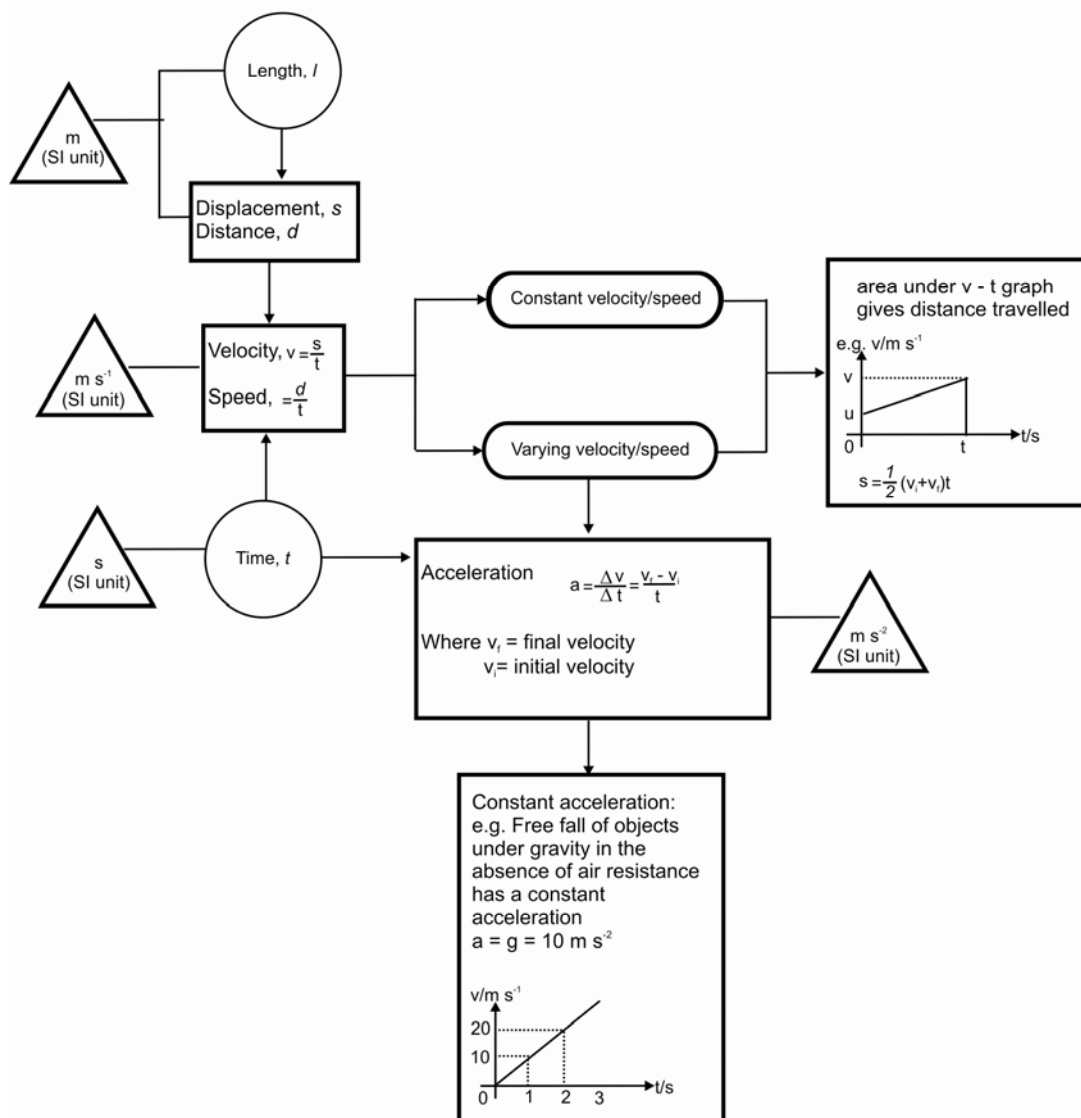
Acknowledgement: Concept maps on the pages 66 to 89 have been extracted and modified from the book *Physics: A course for "O" level* by Charles Chew, Leong See Cheng, Chow Siew Foong.

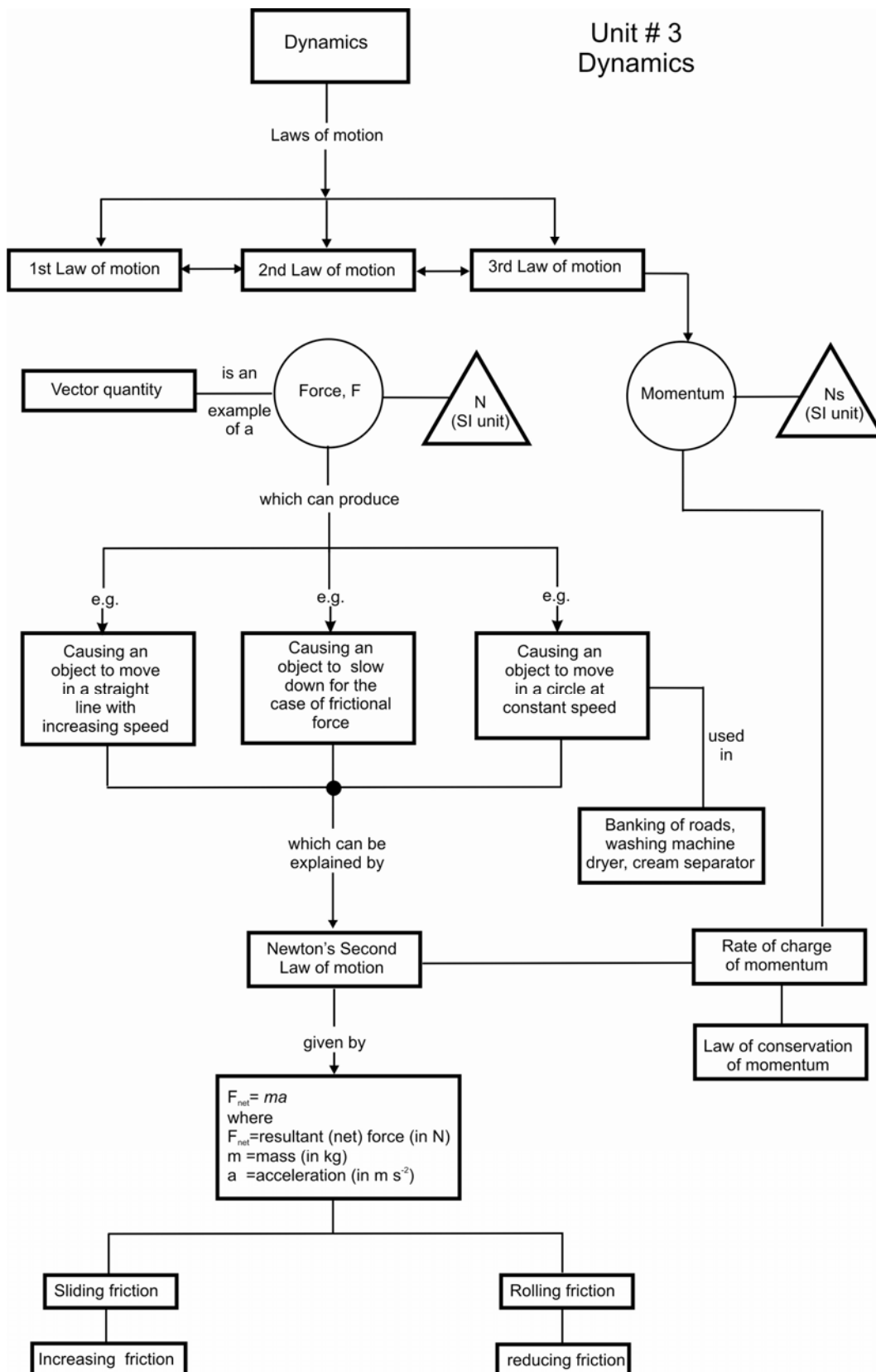
Unit # 1

Physical Quantities and Measurement



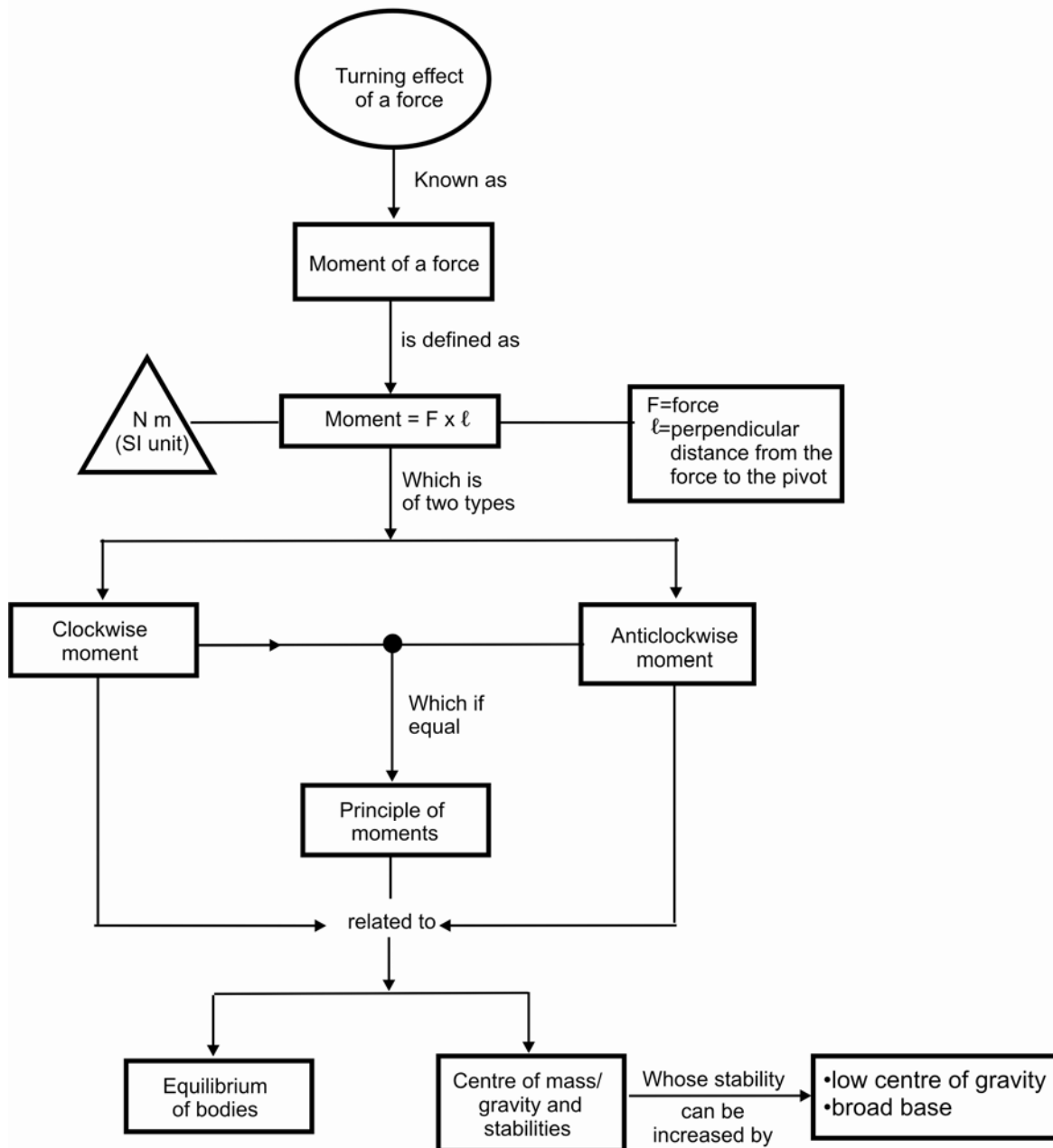
Unit # 2 Kinematics





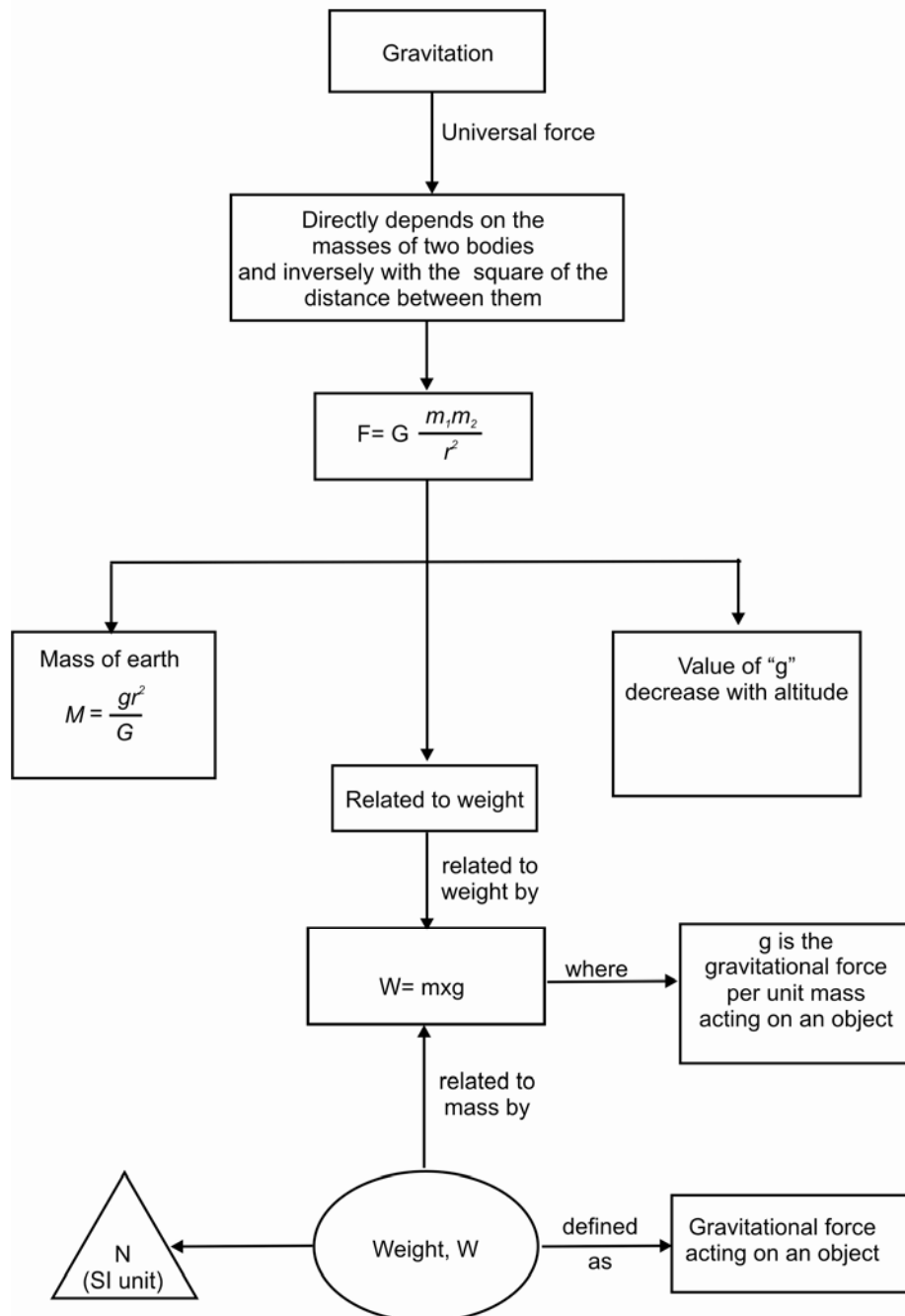
Unit # 4

Turning effect of a Force

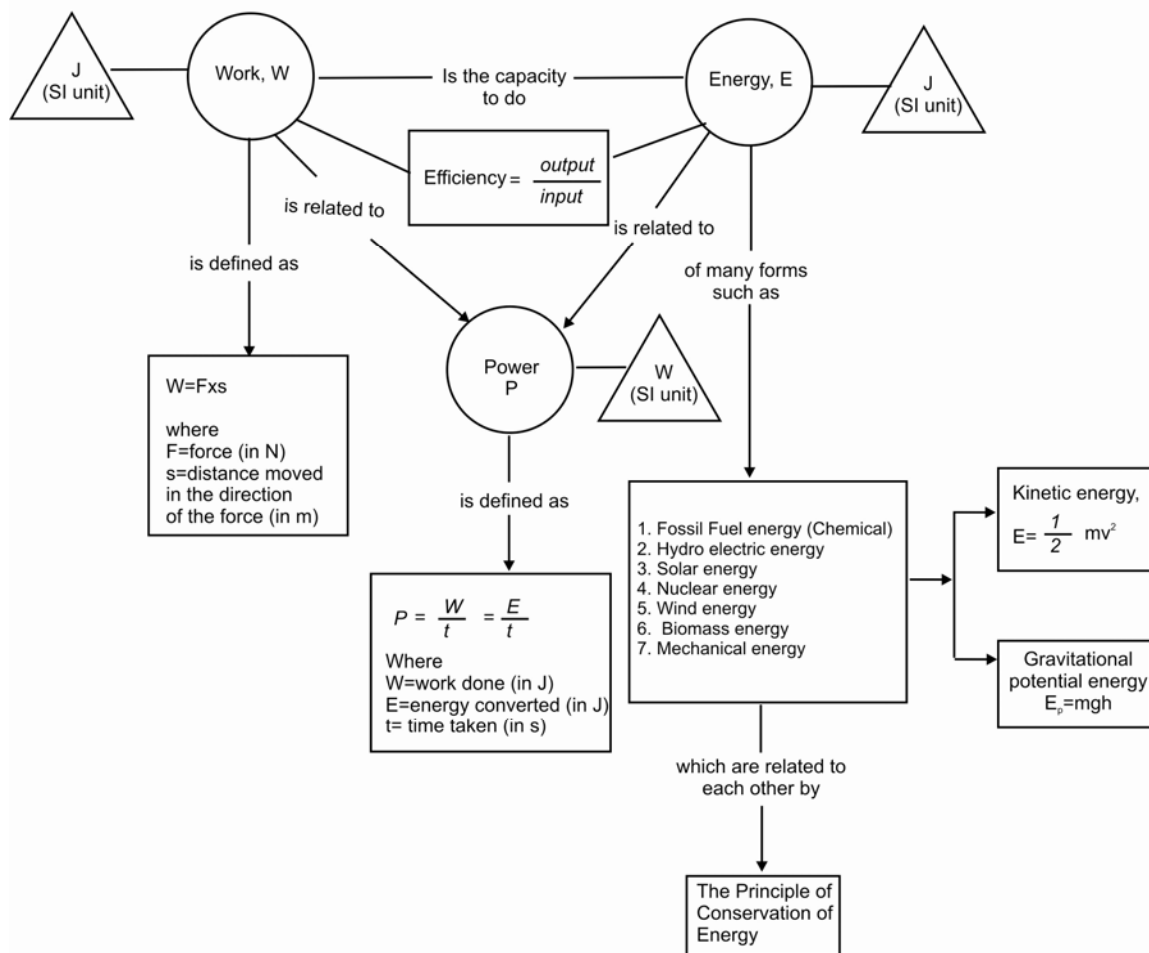


Unit # 5

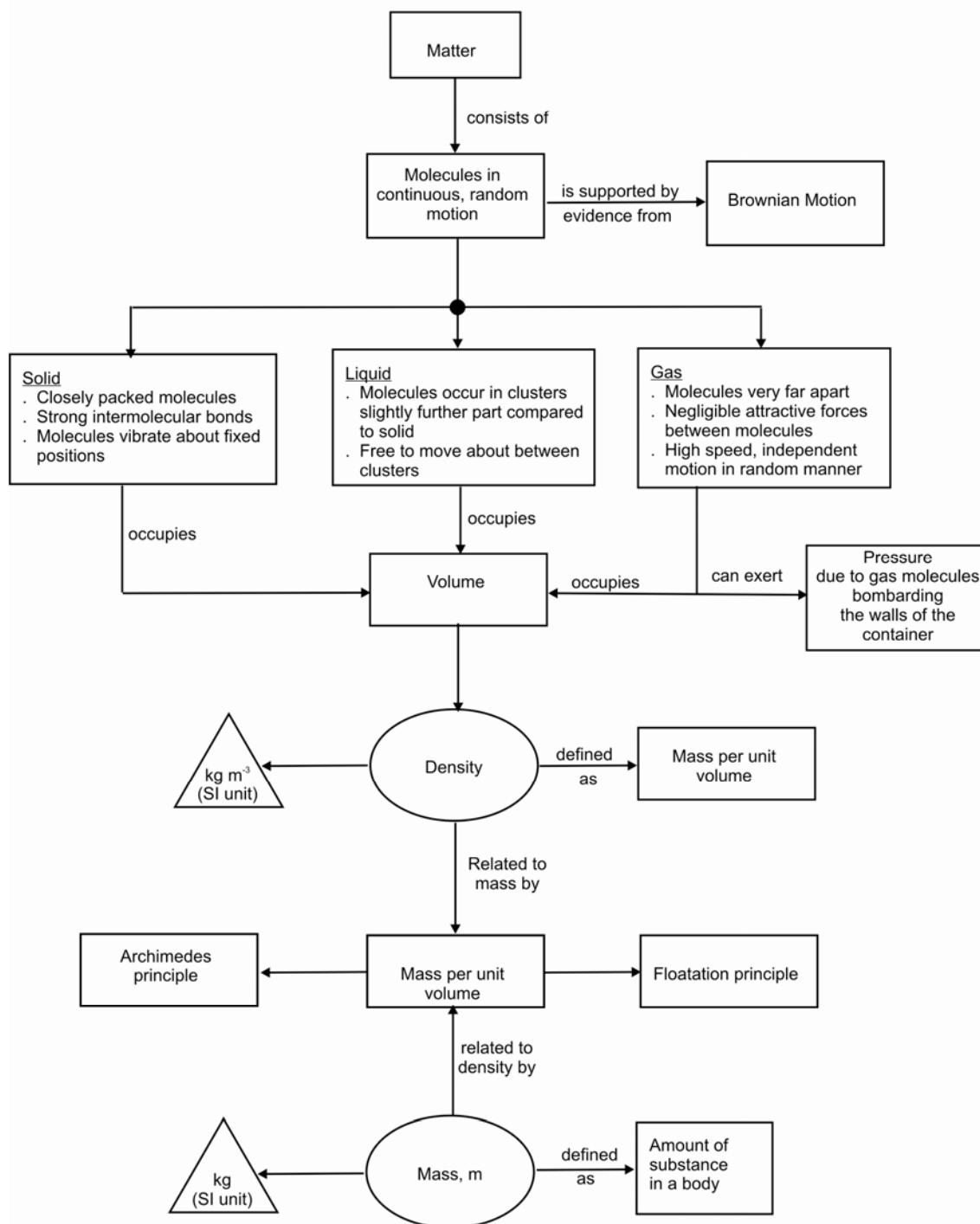
Gravitation



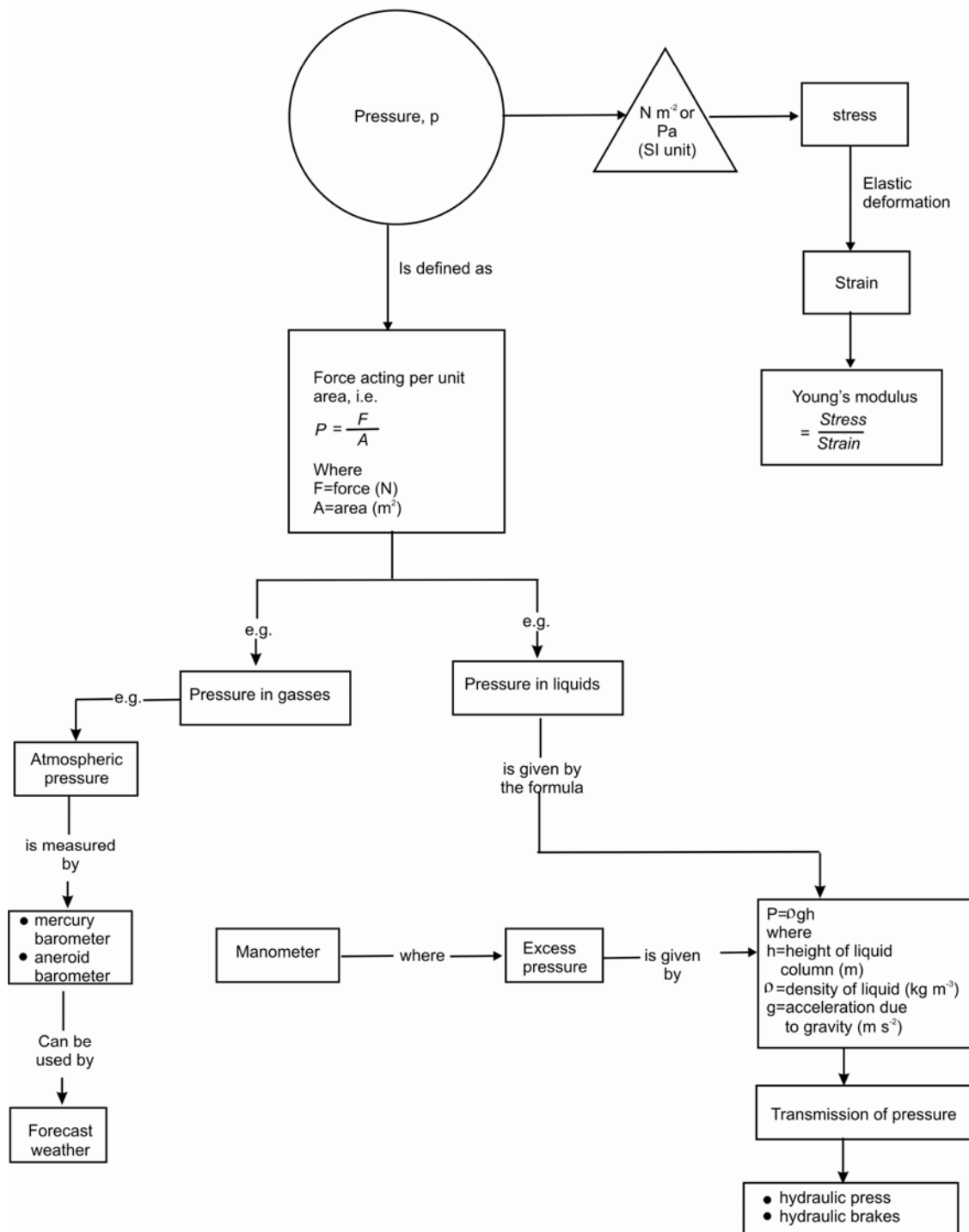
Unit # 6 Work & Energy



Unit # 7 (a) Properties of Matter

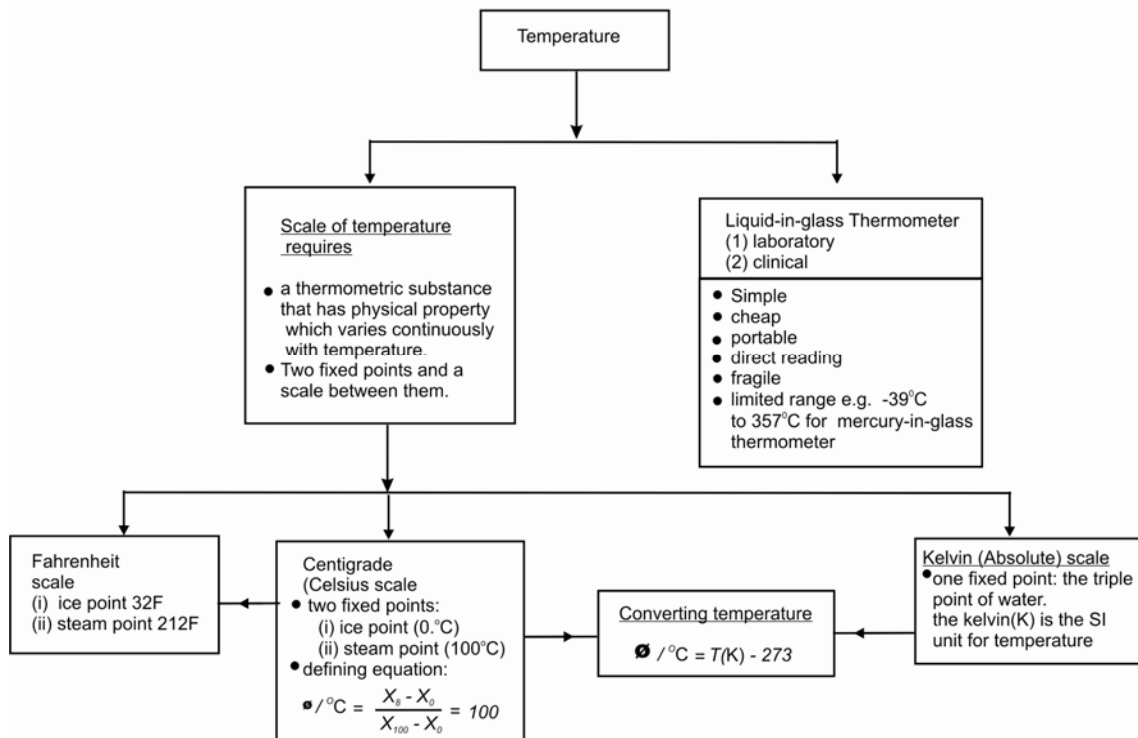


Unit # 7 (b) Properties of Matter



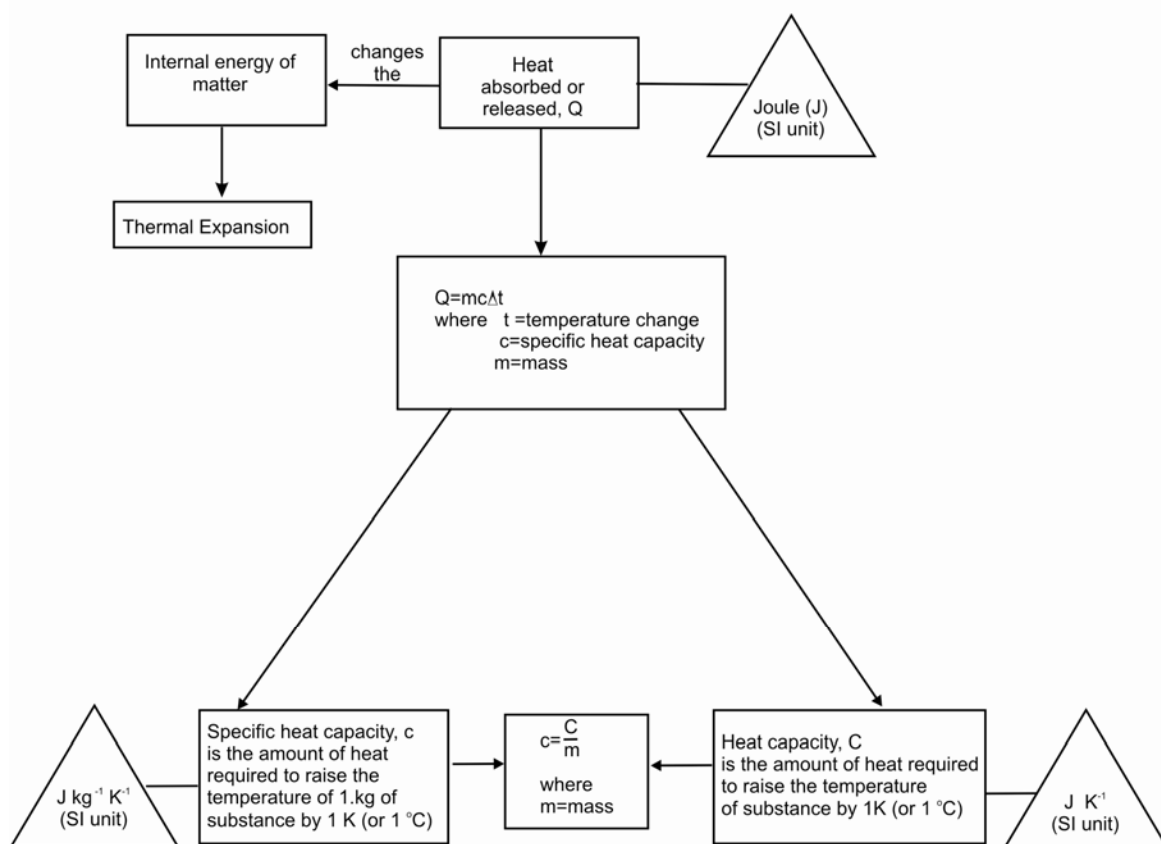
Unit # 8 (a)

Thermal Properties of Matter



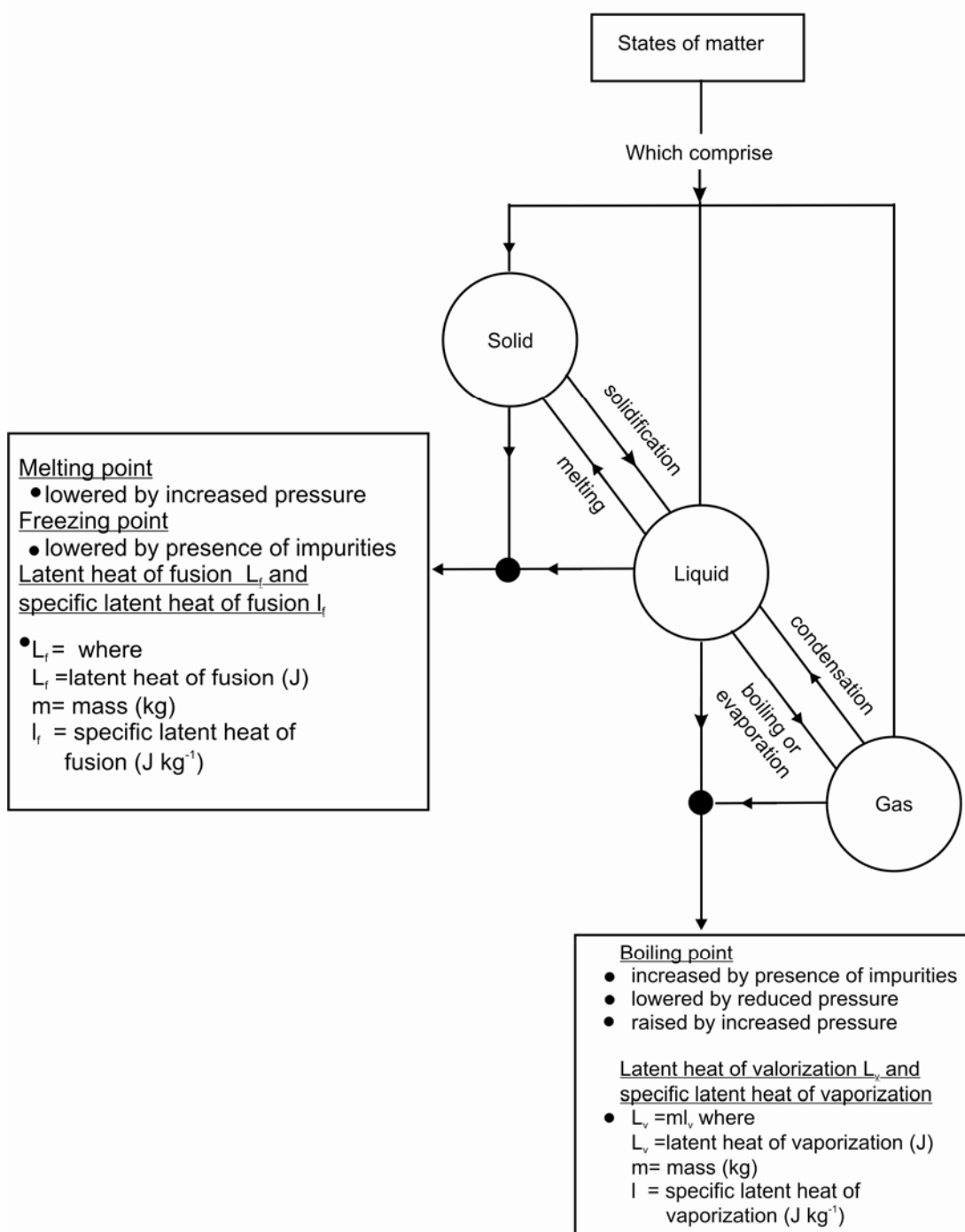
Unit # 8 (b)

Thermal Properties of Matter



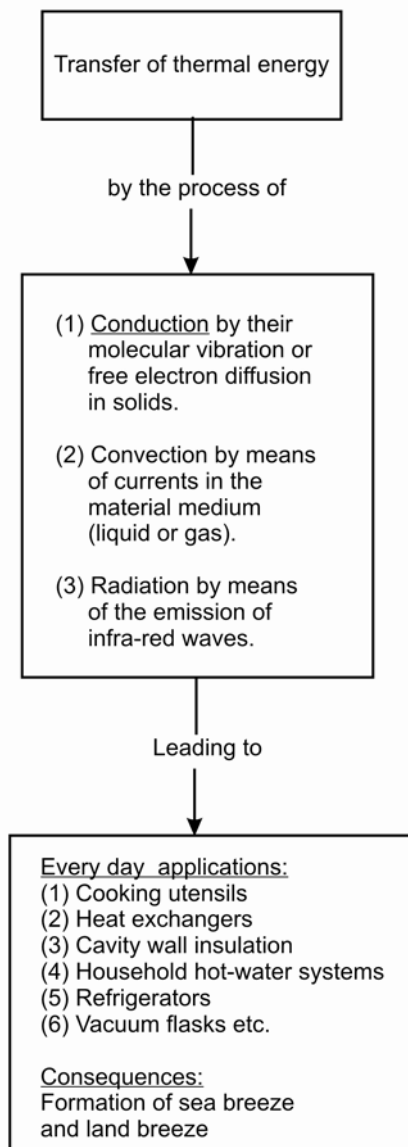
Unit # 8 (c)

Thermal Properties of Matter

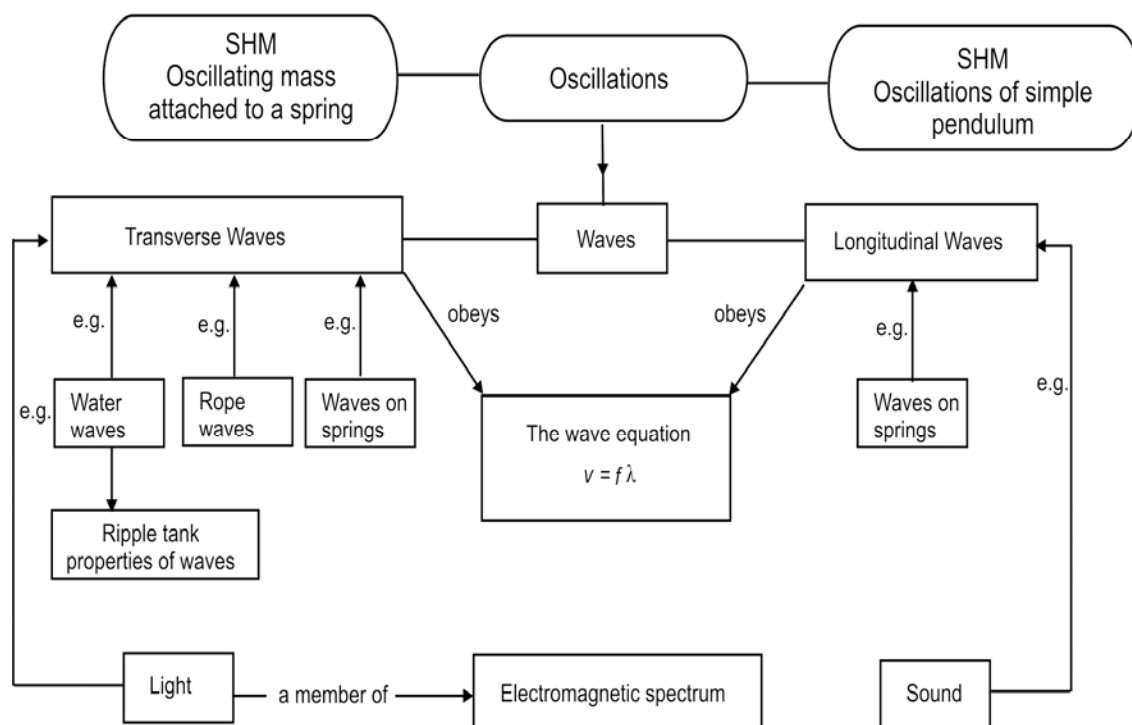


Unit # 9

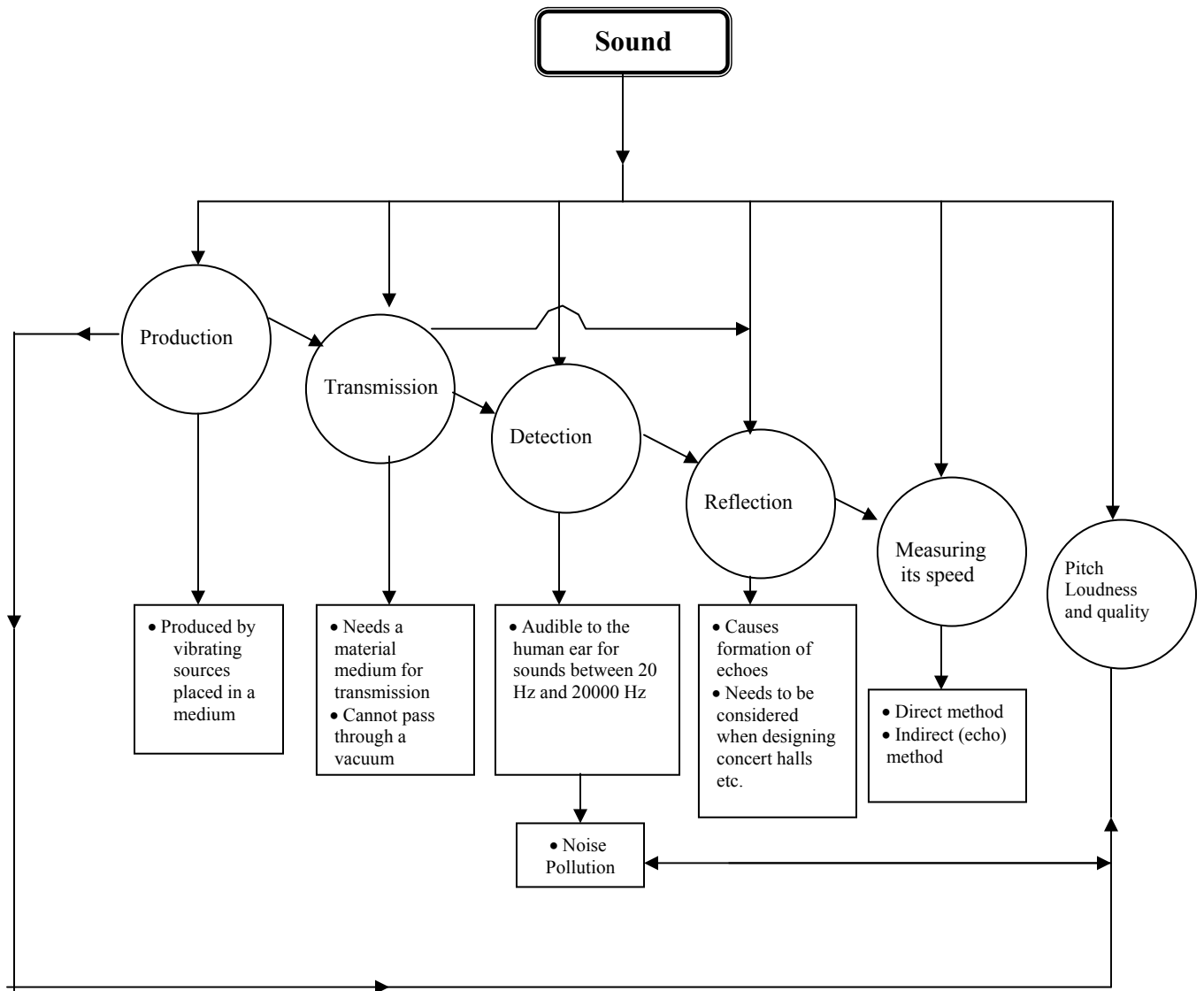
Transfer of Heat (Thermal for Energy)



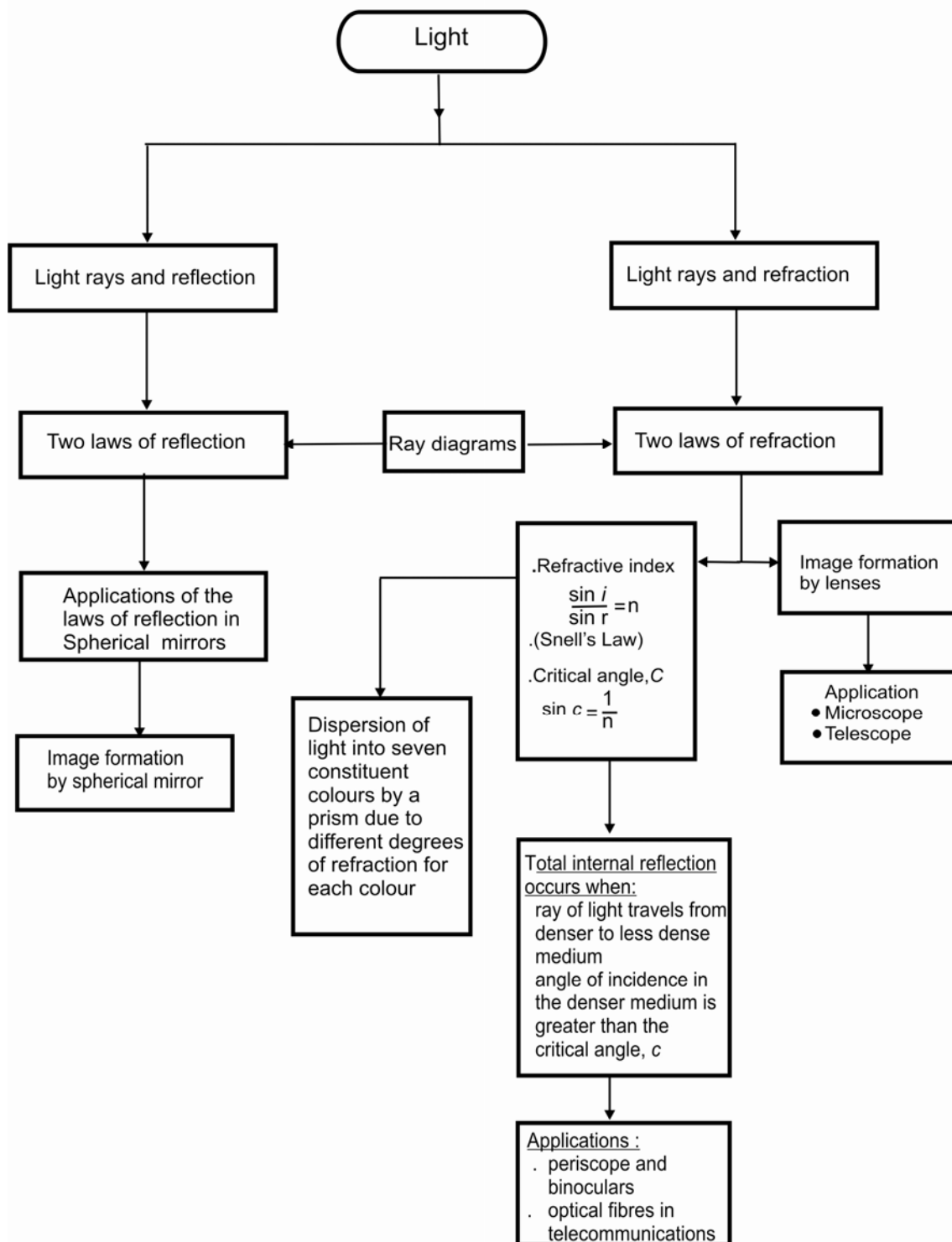
Unit # 10 SHM AND WAVES



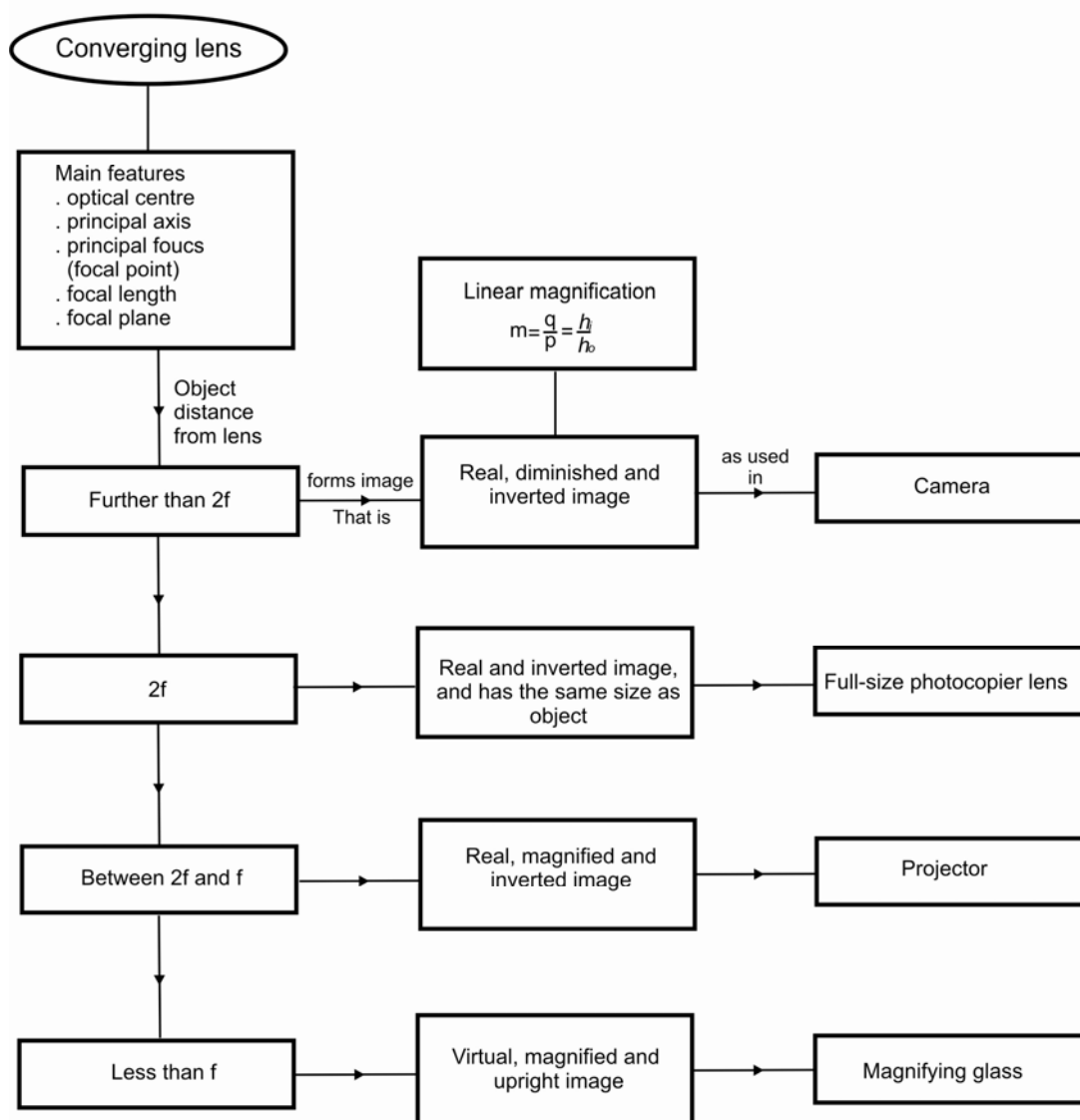
Unit -11



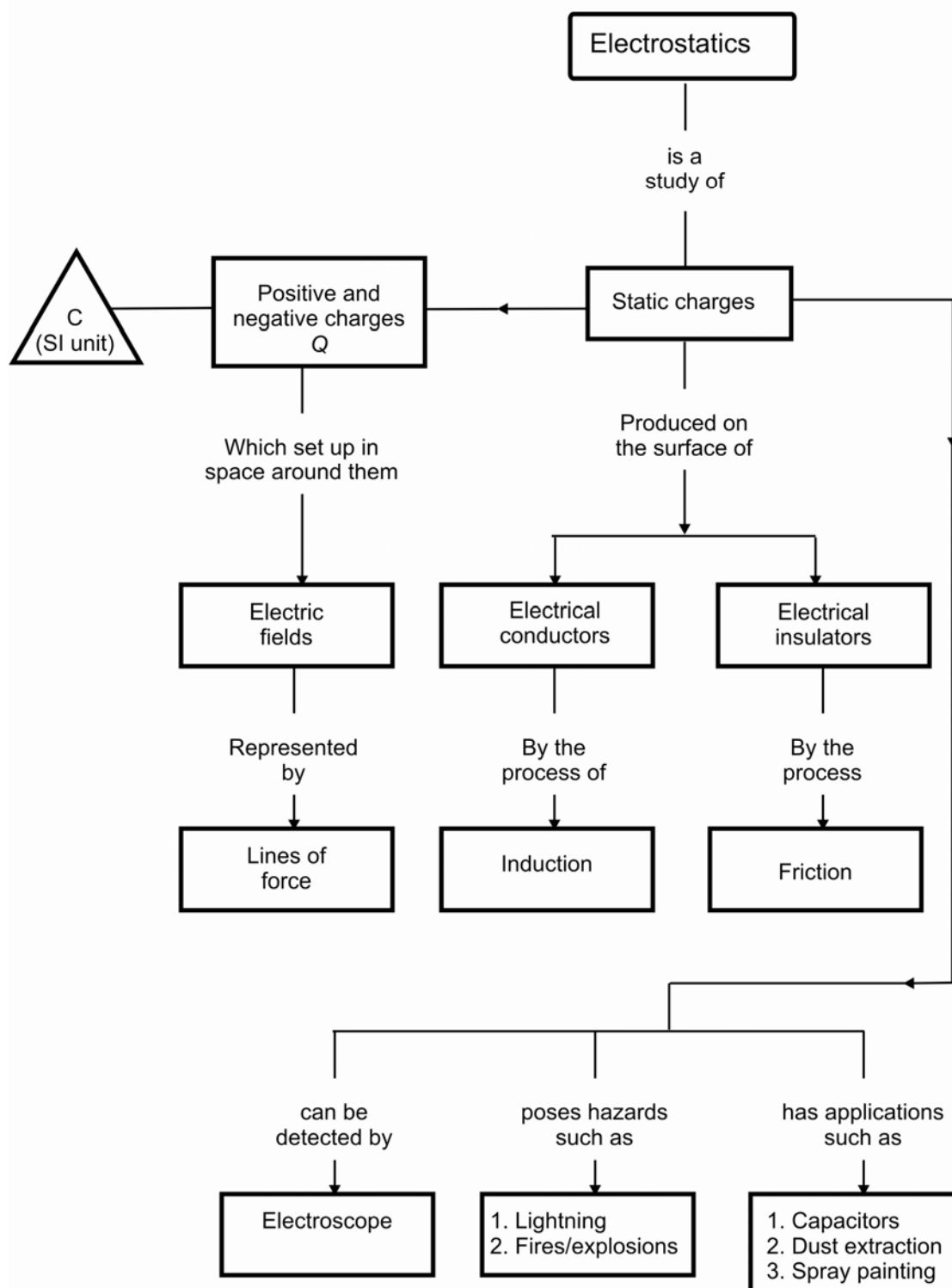
Unit # 12 (a) Geometrical Optics



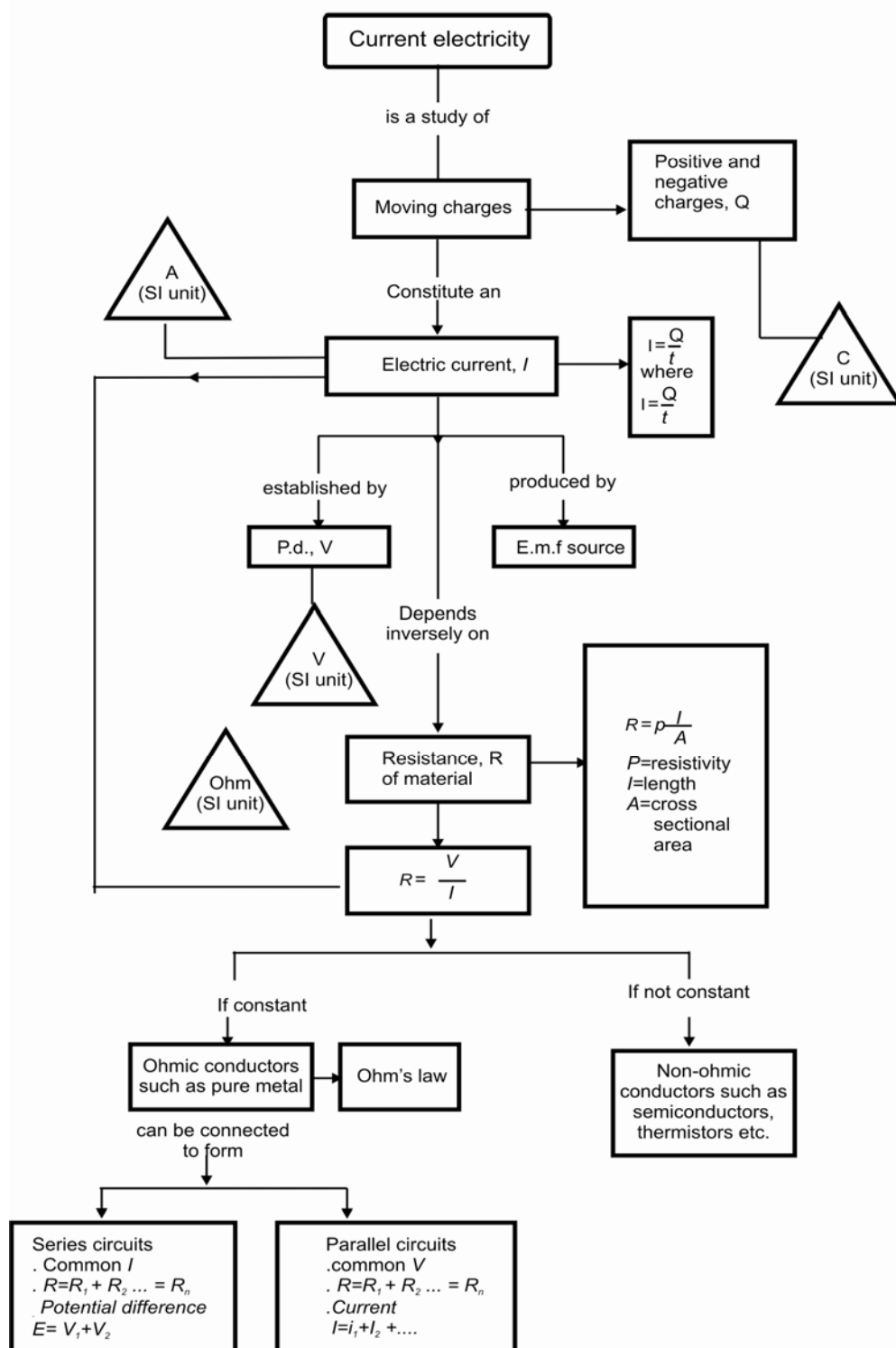
Unit # 12 (b) Geometrical Optics



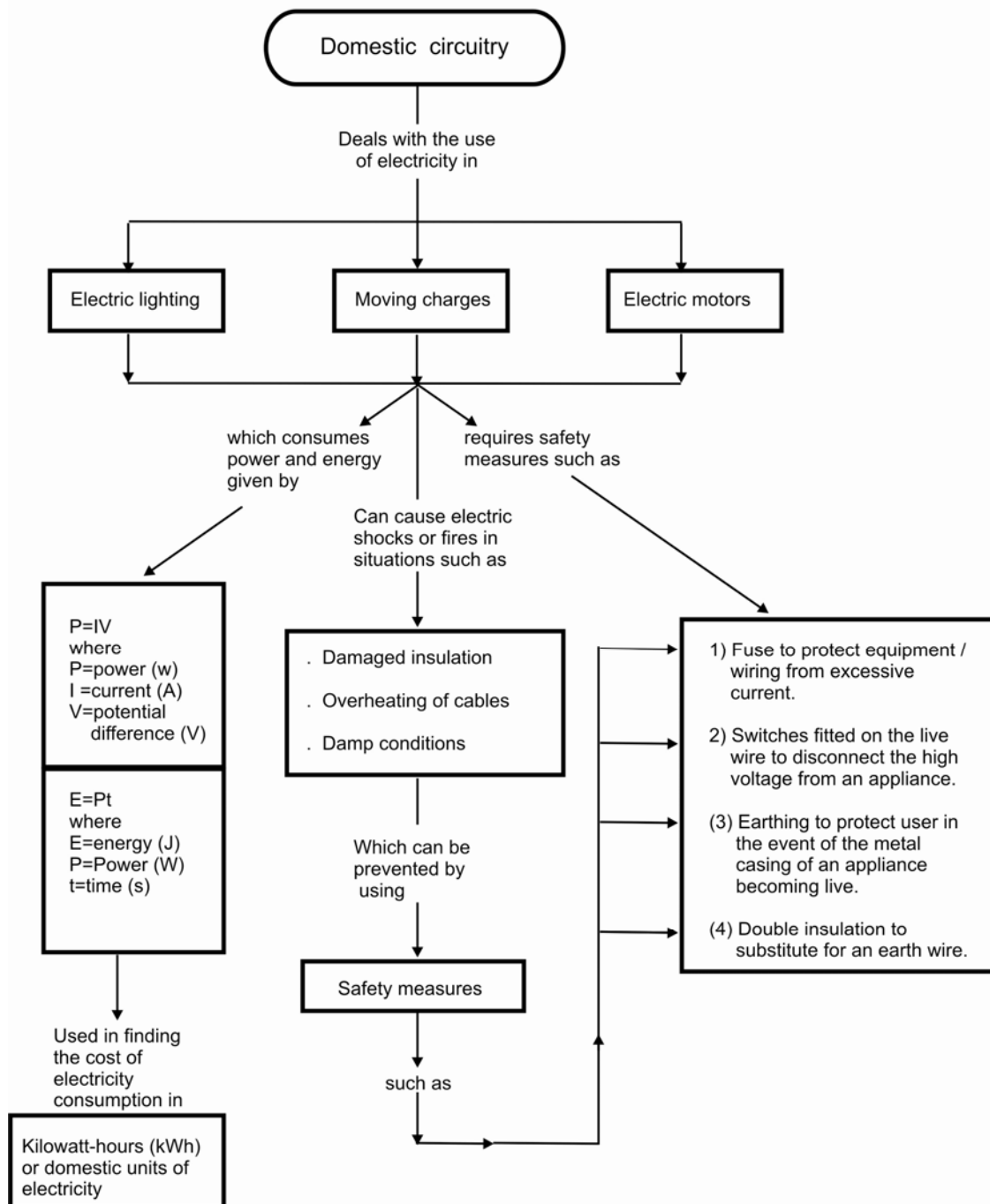
Unit # 13



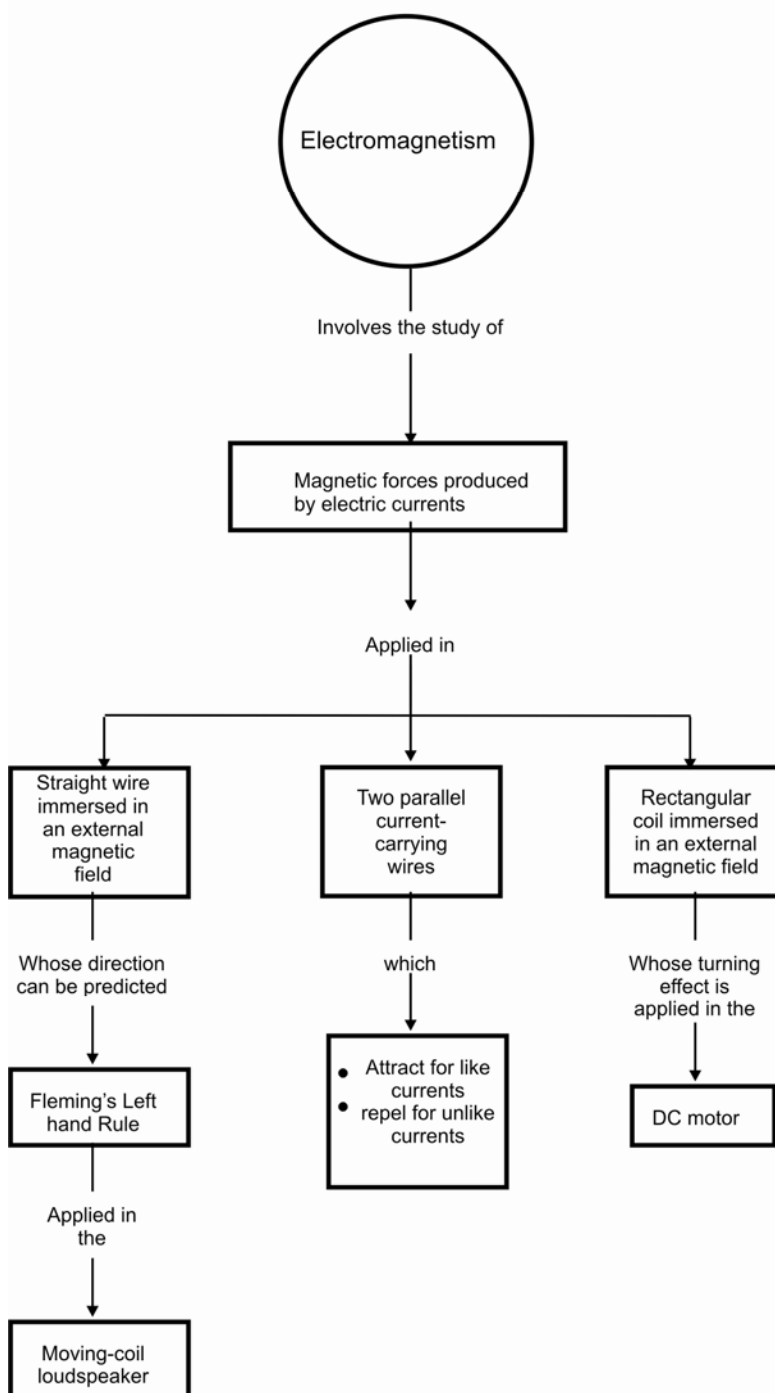
Unit # 14(a) Current Electricity



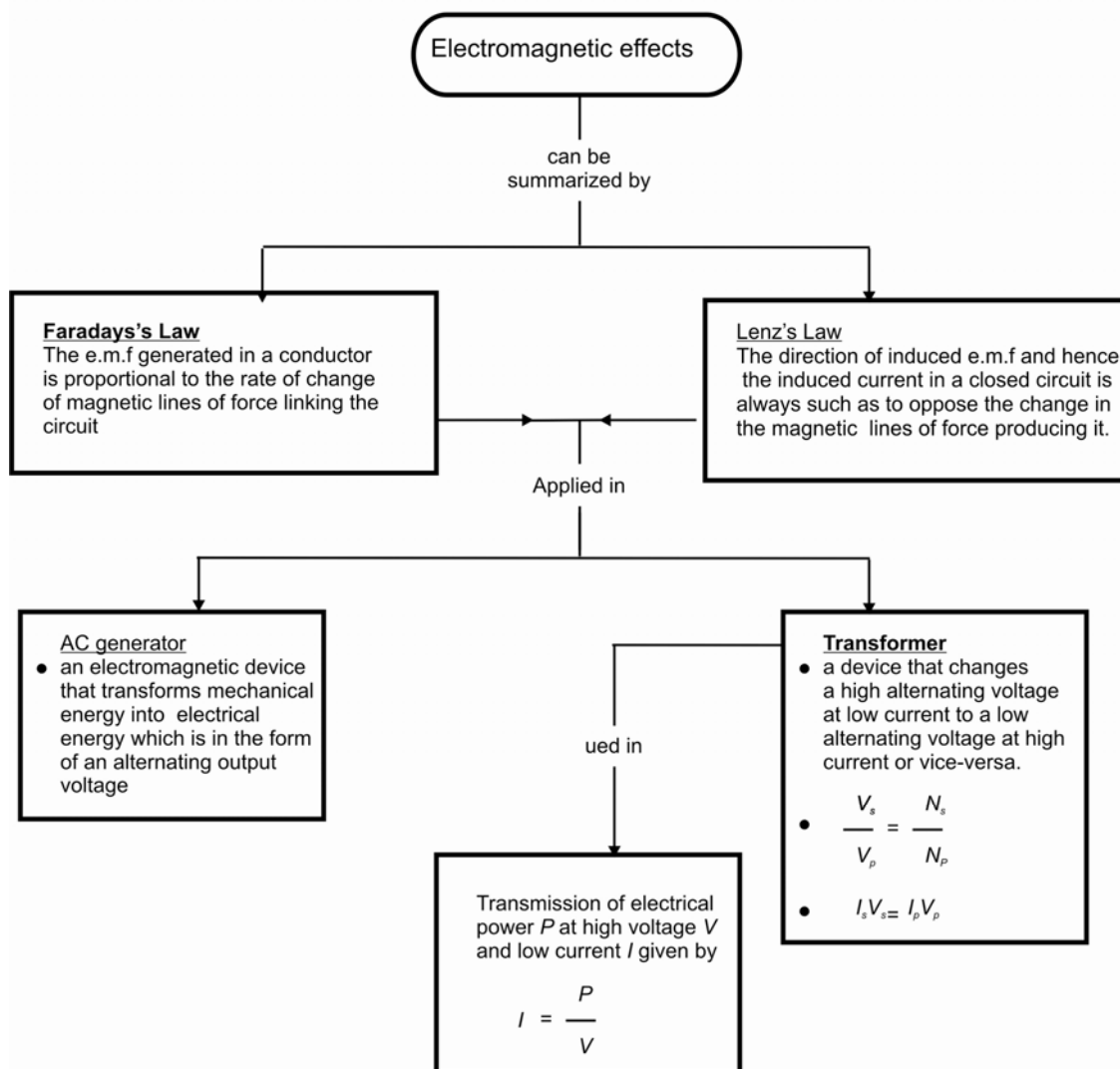
Unit # 14(b) Current Electricity



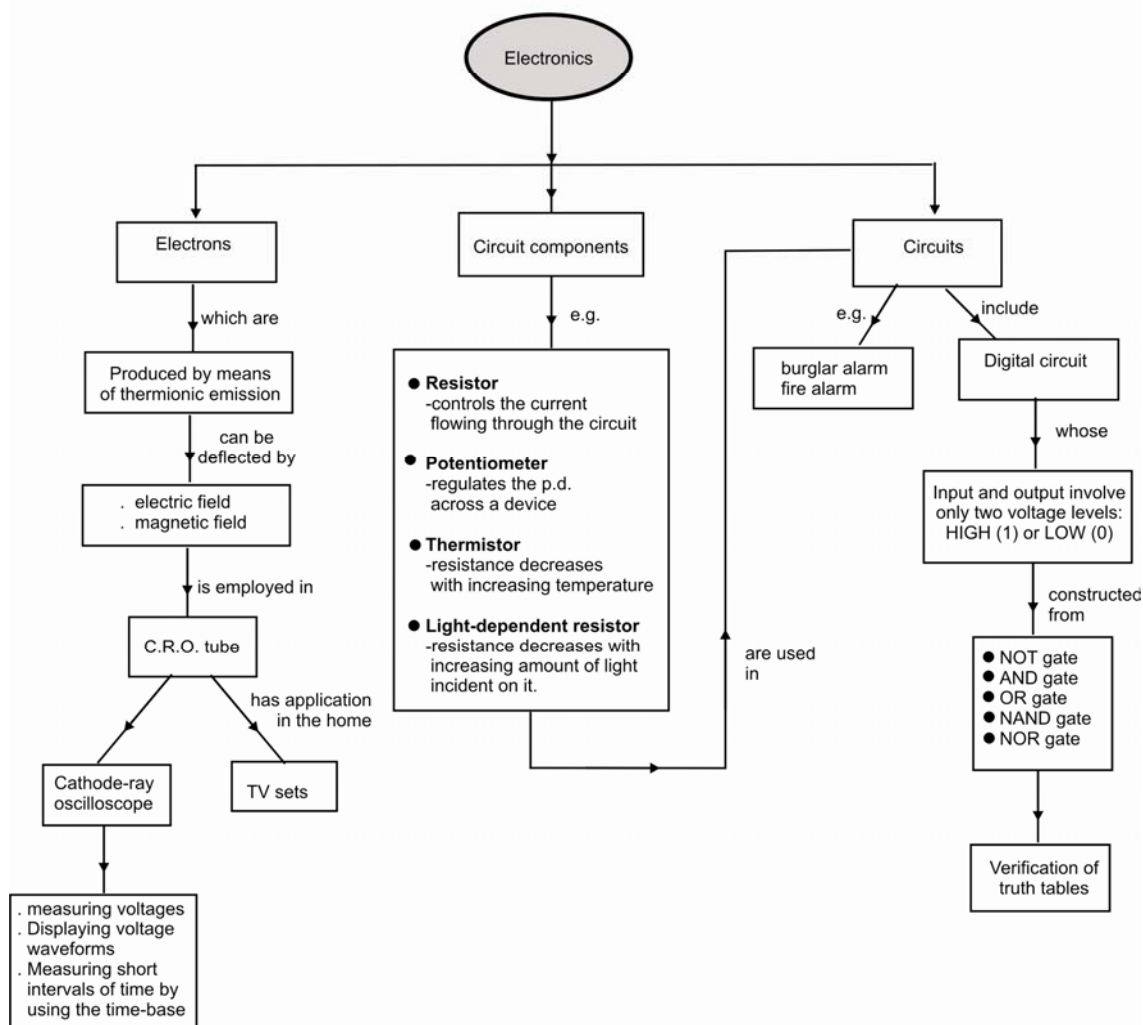
Unit # 15 (a) Electromagnetism



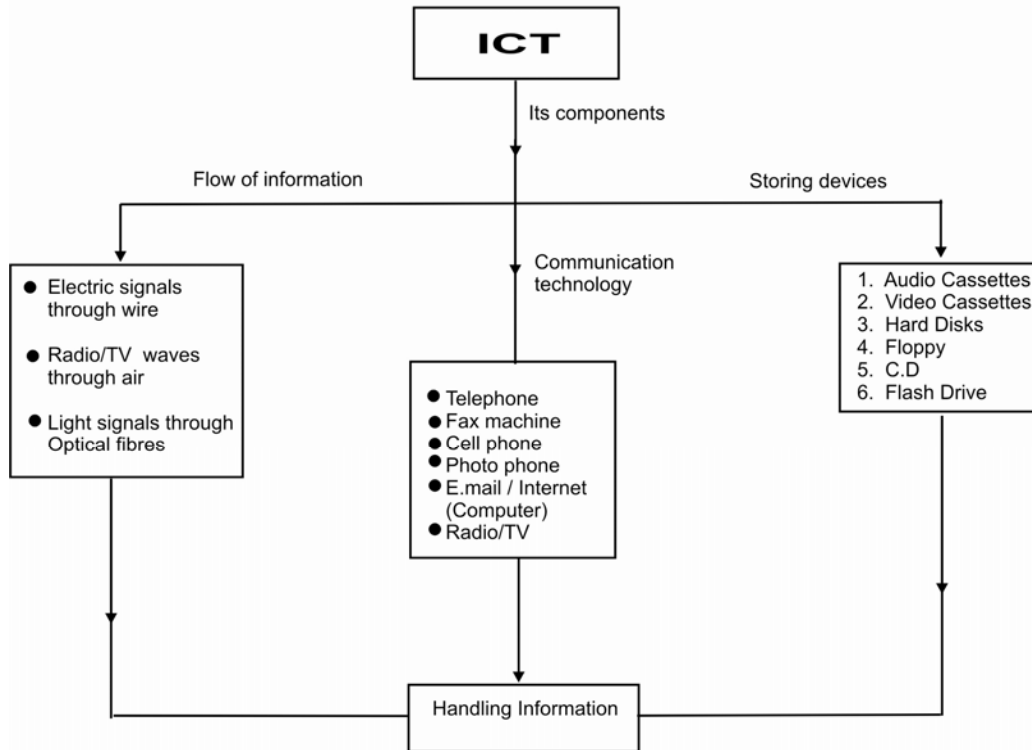
Unit # 15 (b) Electromagnetism



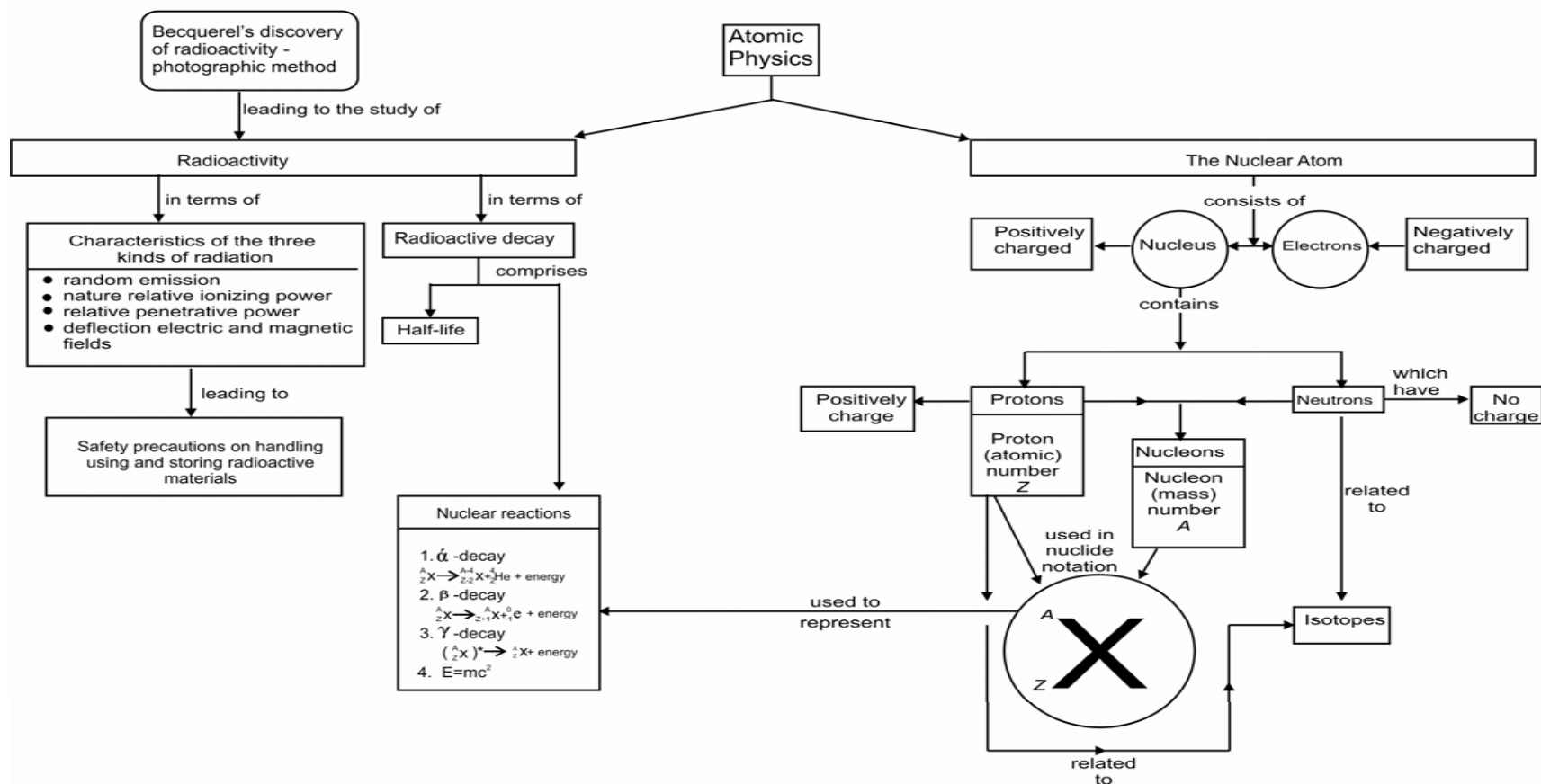
Unit # 16 Introductory Electronics



Unit # 17 Information & Communication Technology (ICT)



Unit # 18 Atomic and Nuclear Physics



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.

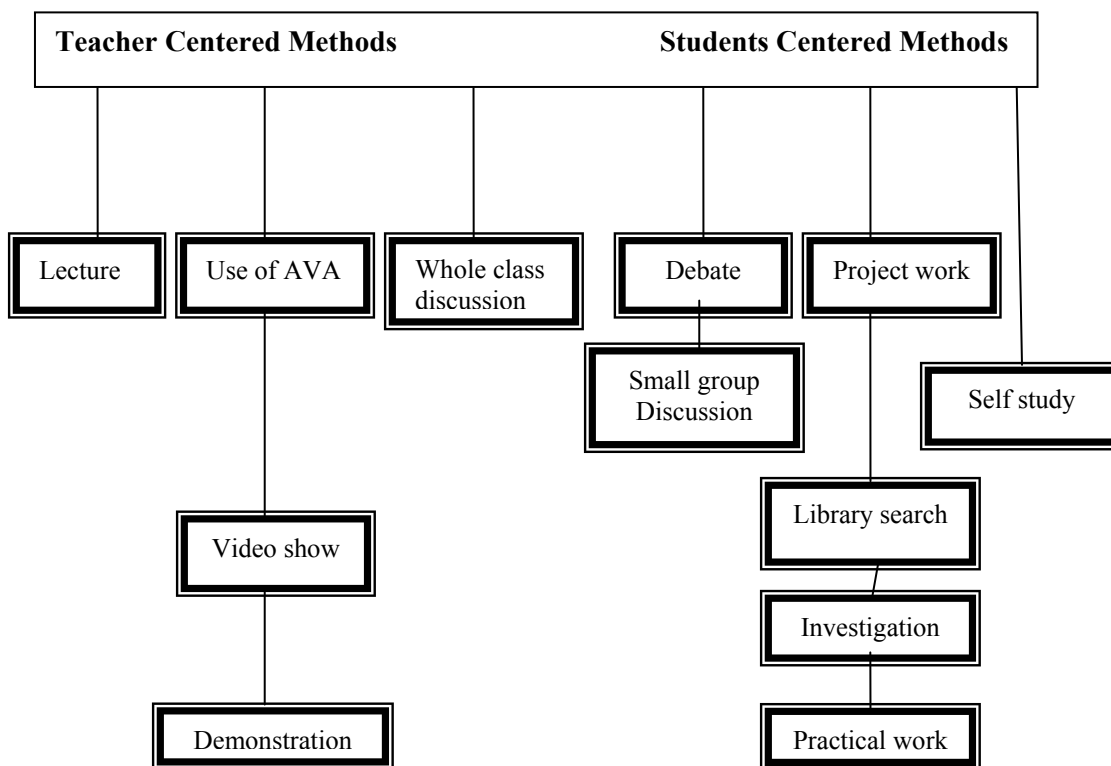
Quantitative treatment is a feature of physics. However, teacher must keep the emphasis on the understanding of the physical interpretation of theoretical formulate and experimental data.

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 Investigation Skills. The development of psychomotor Investigation 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.

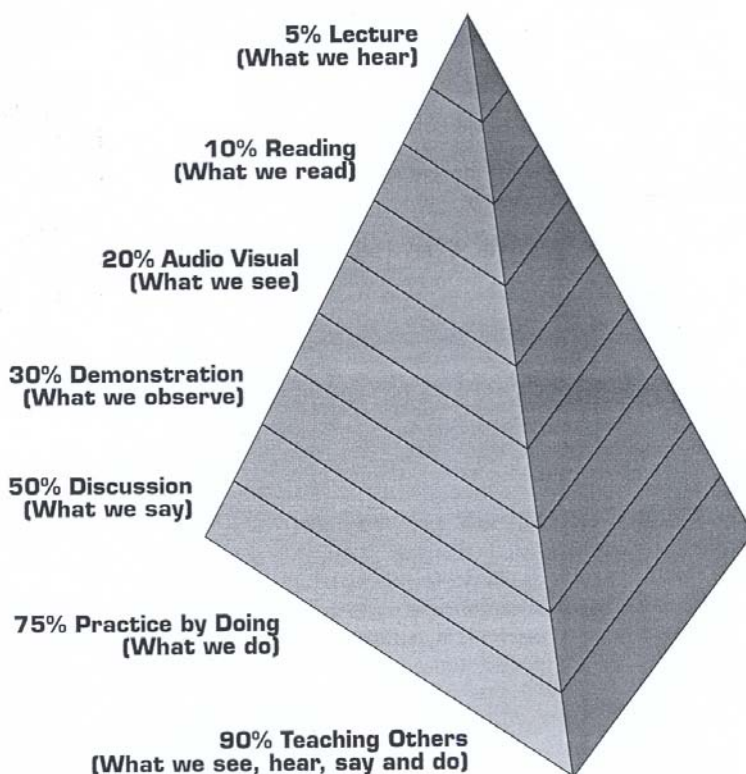
TEACHING / INSTRUCTIONAL STRATEGIES

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 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 Investigation Skills/ Laboratory work
- 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 centers. 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 Investigation Skills/ Laboratory work.
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, analyze 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.

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