G.C.E. (Advanced Level)

PHYSICS

Grade 12

Teachers' Guide
(Implemented from 2017)

Department of Science
Faculty of Science and Technology
National Institute of Education

Physics

Teachers' Guide

Grade 12

First Print – 2017

Department of Science

Faculty of Science & Technology

National Institute of Education

Message from the Director General…

With the primary objective of realizing the National Educational Goals recommended by the National Education Commission, the then prevalent content based curriculum was modernized, and the first phase of the new competency based curriculum was introduced to the eight year curriculum of the primary and secondary education in Sri Lanka in the year 2007.

The second phase of the curriculum cycle thus initiated was introduced to the education system in the year 2015 as a result of a curriculum rationalization process based on research findings and various proposals made by stake holders.

Within this rationalization process the concepts of vertical and horizontal integration have been employed in order to build up competencies of students, from foundation level to higher levels, and to avoid repetition of subject content in various subjects respectively and furthermore, to do develop a curriculum that is implementable and student friendly.

The new Teacher's Guides have been introduced with the aim of providing the teachers with necessary guidance for planning lessons, engaging students effectively in the learning teaching process, and to make Teachers' Guides will help teachers to be more effective within the classroom. Further, the present Teachers' Guides have given the necessary freedom for the teachers to select quality inputs and activities in order to improve student competencies. Since the Teachers' Guides to not place greater emphasis on the subject content prescribed for the relevant grades, it is very much necessary to use these guides along with the text books complied by the Educational Publications Department if, Guides are to be made more effective.

The primary objective of this rationalized new curriculum, the new Teachers' Guides, and the new prescribed texts is to transform the student population into a human resource replete with the skills and competencies req2uired for the world of work, through embarking upon a pattern of education which is more student centered and activity based.

I wish to make use of this opportunity to thank and express my appreciation to the members of the Council and the Academic Affairs Board of the NIE the resource persons who contributed to the compiling of these Teachers' Guides and other parties for their dedication in this matter.

Dr.(Mrs.) Jayanthi Gunasekara
Director General
National Institute of Education
Maharagama.

Message from the Deputy Director General

Education from the past has been constantly changing and forging forward. In recent years, these changes have become quite rapid. The Past two decades have witnessed a high surge in teaching methodologies as well as in the use of technological tools and in the field of knowledge creation.

Accordingly, the National Institute of Education is in the process of taking appropriate and timely steps with regard to the education reforms of 2015.

It is with immense pleasure that this Teachers' Guide where the new curriculum has been planned based on a thorough study of the changes that have taken place in the global context adopted in terms of local needs based on a student-centered learning-teaching approach, is presented to you teachers who serve as the pilots of the schools system.

An instructional manual of this nature is provided to you with the confidence that, you will be able to make a greater contribution using this.

There is no doubt whatsoever that this Teachers' Guide will provide substantial support in the classroom teaching-learning process at the same time. Furthermore the teacher will have a better control of the classroom with a constructive approach in selecting modern resource materials and following the guide lines given in this book.

I trust that through the careful study of this Teachers Guide provided to you, you will act with commitment in the generation of a greatly creative set of students capable of helping Sri Lanka move socially as well as economically forward.

This Teachers' Guide is the outcome of the expertise and unflagging commitment of a team of subject teachers and academics in the field Education.

While expressing my sincere appreciation for this task performed for the development of the education system, my heartfelt thanks go to all of you who contributed your knowledge and skills in making this document such a landmark in the field.

M.F.S.P. Jayawardhana
Deputy Director General
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List of topics and allocated number of periods

	Topic	Number of Periods
Unit 01	Mesurement	30
Unit 02	Mechanics	100
Unit 03	Oscillations and Waves	100
Unit 04	Thermal Physics	60
Unit 05	Gravitational Field	20
Unit 06	Electrostatic field	60
Unit 07	Magnetic Field	40
Unit 08	Current Electricity	70
Unit 09	Elecronics	40
Unit 10	Mechanical Properties of Matter	40
Unit 11	Matter and Radiation	30
	Total =	**600**

Content

Unit 1:Measurements

Competency 1:- **Uses experimental and mathematical background in physics for systematic analysis.**

Competency Level 1.1:- Inquires the scope of physics and how to use the scientific methodology for exploration.

No of Periods:- 02

Learning outcomes:-

- explains physics as the study of energy, behavior of matter in relation to energy and transformation of energy.
- describes physics as a subject that focuses from fundamental particles to the Universe.
- expresses how to use principles of physics in day-to-day life and to explain natural phenomena.
- elaborates how physics has been applied in development of new technologies in areas such as
  - Transportation
  - Communication
  - Energy production and energy usage
  - Medicine
  - Earth and space explorations
- uses the scientific method for scientific explorations.
- accepts that advancements in physics are based on observations and inferences made on them

Suggested learning/teaching process

- Conduct a discussion recalling relevant subject matter learnt in O/L Science and introduce physics as the study of energy, behavior of matter in relation to energy and transformation of energy.
- Conduct a discussion regarding
  - Advancement of physics due to the discoveries of great scientists such as Newton, Albert Einstein, etc.
  - Basic methodologies used by scientists for their discoveries such as observation, experimentation, measurement and calculation.
  - Contribution of physics for human needs such as vision, hearing, etc.
  - Natural phenomena such as earth quakes, weather and climate, etc.
  - Applications of physics in transportation, communication, energy generation and energy usage, bio medical sciences, etc.
  - Introduce the main steps of scientific method

Competency Level 1.2.: **Uses physical quantities and appropriate units in scientific work and daily pursuits**.

No of Periods: 04

Learning outcomes:-

- identifies basic physical quantities and derived physical quantities.
- uses appropriate SI base units and derived SI units.
- appreciates that all physical quantities consist of a numerical magnitude with or without a unit.
- uses the prefixes and their symbols to indicate multiples and submultiples.
- converts units appropriately.
- uses the knowledge of scientific notation.

Suggested learning/teaching process

- Introduce mass, length, time, electric current, thermodynamic temperature, luminous intensity, and amount of substance as the seven fundamental quantities.
- Introduce plane angle and solid angle as two supplementary quantities.
- Explain using examples that all the physical quantities consist of numerical magnitude with or without units.
- State the ranges involved in mass, length and time measurements.
- Introduce SI units and symbols of fundamental quantities and supplementary quantities.

Basic (fundamental) Quantities	Unit	Symbol
Mass	kilogram	kg
Length	metre	m
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous Intensity	candela	cd
Amount of substance	mole	mol
Plane angle	radian	rad
Solid angle	steradian rad	sr

Table 1.1 Seven basic SI Units and two supplementary units

- Explain that quantities such as area, volume, density, speed, acceleration, force etc can be expressed in terms of fundamental quantities and name them as derived physical quantities.

- Introduce the special names and their symbols of the derived units.
- Select few physical quantities learnt in the O/L class and tabulate them with their SI units.

Derived Quantity	Unit	
	Name	Symbol
Force	newton	$N = kg\ m\ s^{-2}$
Pressure	pascal	$Pa = kg\ m^{-1}\ s^{-2}$
Energy, Work	joule	$J = kg\ m^{2}\ s^{-2}$
Power	watt	$W = kg\ m^{2}\ s^{-3}$
Frequency	hertz	$Hz = s^{-1}$
Electric Charge	coulomb	$C = A\ s$
Electromotive force	volt	$V = kg\ m^{2}\ s^{-3}\ A^{-1}$
Electrical Resistance	ohm	$\Omega = kg\ m^{2}\ s^{-3}\ A^{-2}$
Electrical Conductance	siemen	$S = kg^{-1}\ m^{-2}\ s^{3}\ A^{2}$
Permeability	henry	$H = kg\ m^{2}\ s^{-2}\ A^{-2}$
Capacity	farad	$F = kg^{-1}\ m^{-2}\ s^{4}\ A^{2}$
Magnetic flux	weber	$Wb = kg\ m^{2}\ s^{-2}\ A^{-1}$
Magnetic flux density	tesla	$T = kg\ s^{-2}\ A^{-1}$

Table 1.2 Special names and symbols of some derived quantities

- Explain the use of multiples and submultiples of SI units. Introduce the prefixes with symbols.

Multiple or sub multiple (prefix)	Symbol	Multiplied factor
deci	d	10^{-1}
centi	c	10^{-2}
mili	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}
kilo	k	10^{3}
mega	M	10^{6}
giga	G	10^{9}
tera	T	10^{12}

Table 1.3 multiples and submultiples

- Introduce the rules to be obeyed in writing SI units
  - State that the prefix is written in front of the basic SI unit with no space between the two symbols.
    eg:- mm, μm

    - State that the method of expressing the multiplication of units is to write the symbols with a single space between them.
      eg:- N m
- State a few examples of physical quantities which do not have units.
  eg:- relative density, refractive index
- Select a few examples and familiarize how to write the values with corresponding units.
  eg:- $10\ \mathrm{N}$, $5\ \mathrm{m\ s^{-1}}$

Competency Level 1.3:- **Investigates physical quantities using dimensions**

No of Periods:- 04

Learning outcomes:- students will be able to;-

- identifies dimensions of basic physical quantities used in mechanics
- checks the correctness of equations dimensionally.
- uses dimensions to derive expressions
- uses dimensions to determine units of physical quantities.

Suggested learning/teaching process

- Introduce that dimensions of mass, length and time are denoted by M, L and T respectively.
- Guide students to find dimensions of derived quantities in terms of above dimensions.
- Explain that the dimensions of a quantity are independent of units using examples such as velocity, acceleration and force.
- Explain that quantities without units such as coefficient of friction have no dimensions. There are quantities with units but without dimensions (eg. plane angle)
- Discuss examples on how to check whether an equation is dimensionally correct.
- Direct students to derive relationships among physical quantities using dimensional analysis (e.g. period of oscillation of a simple pendulum, speed of transverse waves along a stretched string, etc)

Competency Level 1.4: **Obtain measurements accurately by selecting the most appropriate instrument to minimize errors**.

No of Periods: 12

Learning outcomes :

- describes the importance of taking measurements during experiments and in day-to-day activities
- identifies the least count of an instrument
- select suitable measuring instruments for measurements.
- explains vernier principle and micro meter principle
- uses vernier caliper, travelling microscope, micrometer screw gauge, spherometer, triple beam balance, four beam balance electronic balance, stopwatch and digital stop watch to measurements.
- explains the effects of systematic errors (including zero errors) and random errors in measurements.
- calculates fractional error and percentage error.
- appreciates the purpose of calculating fractional error and percentage error.
- determine the depth , internal radius and external radius of a hollow cylinder using a venire caliper.
- determine diameter and thickens of a coin using a micrometer screw gauge.
- determine surface radius of a curved mirror/lense using a spherometer.
- determine internal and external radius of a rubber tube using a travelling microscope.
- calculates density of a regular shape object using suitable measuring instruments out of given instruments.

Suggested learning/teaching process :

- Explain using examples that the selection of measuring instruments are based on the nature and the magnitude of the measurement.
- Explain random error and systematic error.
- Explain the least count and the zero error of measuring instruments.
- Explain the principles of vernier and screw gauges.
- Demonstrate how to use the metre ruler, vernier calliper, micrometer screw gauge, spherometer, travelling microscope, digital stop watch, electronic balance, triple beam balance and four beam balance.
- Guide the students to perform the following activities

- Measure the length, breadth and thickness of a block of wood using different measuring instruments.
- Measure mass using triple beam balance, four beam balance and electronic balance.
- Measure time using digital stop watch.
- Calculate and compare the fractional error and percentage error of each measurement.

$$fractional\ error = \frac{least\ count}{measurement}$$

- Stress the importance of the least count.

Laboratory practicals

Use of measuring instruments

- Vernier calliper
- Micrometer screw gauge
- Spherometer
- Travelling microscope

Competency Level 1.5: Uses vector addition and resolution appropriately.

No of Periods: 08

Learning outcomes :

- distinguishes between scalar and vector quantities and give examples of each.
- represents a vector geometrically.
- add and subtract coplanar vectors.
- finds the resultant of two inclined vectors using vector parallelogram law.
- finds the resultant of vectors using triangle method.
- finds the resultant of vectors using polygon method.
- resolves a vector into two perpendicular components.
- give examples for instances where a single force is applied instead of several forces and vise verse.

Suggested learning/teaching process :

- Conduct a discussion to explain the difference between vector quantities and scalar quantities.
- Guide students to categorize vector quantities and scalar quantities.
- Introduce the geometrical representation of a vector.
- Use the vector triangle method for vector addition.
- Introduce the parallelogram theorem of vectors.
- Guide students to obtain the algebraic expression of parallelogrm law
- Explain the resolution of a vector into two perpendicular components.
- Discuss examples pertaining to addition and subtraction of coplanar vectors.

Unit 2 : Mechanics

Competency level 2.1: **Analyze one dimensional and two dimensional motion**

No. of periods: 15

Learning outcomes :

- gives examples for the instances that can be described using the concept of relative motion.
- writes equations of relative motion using standard symbols.
- calculates the velocity of an object relative to another object moving at constant velocity on parallel paths in the same direction and in opposite directions.
- uses graphs of displacement vs. time and velocity vs. time to calculate displacement, velocity and acceleration as appropriate.
- derives equations of motion using v-t graph.
- uses equations of motion for constant acceleration to describe and predict the motion of an object along a straight path on a horizontal plane, vertical motion under gravity and motion on a frictionless inclined plane.
- describes vertical and horizontal motion of a projectile under gravity.
- calculates the position and velocity of a projectile.
- give examples for the applications related to projectiles.
- represents the motion of an object graphically
- describes the motion of an object using graph of motion
- carries out numerical calculations to solve problems using graphs and equations of motion.

Suggested learning/teaching process:

- Discuss related applications such as apparent movement of the sun around the earth, motion of trees as seen by a passenger in a moving vehicle, motion of rain drops as seen by a person in a moving vehicle.
- Explain the concept of relative motion of a body relative to a certain frame of reference, describing frames of earth.
- Introduce the equation for the relative velocity of one body relative to the other, for motion in parallel directions, that is along the same direction and in opposite directions.
- Guide students to solve problems related to relative motion of two bodies moving in parallel directions.

- Discuss various motions performed by bodies and explain rectilinear motion under constant acceleration.
- Introduce displacement vs time (*s* vs *t*) and velocity vs time (*v* vs *t*) graphs to express a certain linear motion.
- Explain that the gradient of a *s-t* graph represents the velocity and the gradient of a *v-t* graph represents the acceleration.
- Explain that the area under *v-t* graph represents the displacement.
- Guide students to sketch *s-t* graphs and *v-t* graphs to represent a given motion and also to transform a simple *s-t* graph to *v-t* and vise-versa.
- Guide students to solve problems using rough sketch of *s-t* graphs and *v-t* graphs.
- Guide students to analyze the motion of an object using given *s-t* and *v-t* graphs.
- Derive the equations of motion using a suitable *v-t* graph.

  $$v = u + at$$

  $$s = \left(\frac{u+v}{2}\right)t$$

  $$s = ut + \frac{1}{2}at^2$$

  $$v^2 = u^2 + 2as$$
- Describe and predict the motion under constant acceleration of an object along a straight line, horizontal motion, vertical motion under gravity and motion on a frictionless inclined plane.
- Guide students to calculate position and velocity of a projectile using equations of motion.
- Describe the path of an object projected with an inclination under gravity using vertical and horizontal components of motion of the object.
- Guide students to use equations of motion to calculate variables related to projectile such as velocity, displacement and to predict where the projectile will land.
- Discuss various relevant applications such as firing of a cannon, a batsman striking a ball in a game of cricket.

Competency level 2.2: **Uses resultant force and moment of a force to determine the centre of gravity of a body**

No. of periods: 15

Learning outcomes :

- describe the resultant of forces.
- writes an algebraic expression for the resultant of forces using parallelogram law.
- uses force resolution method and force parallelogram law to find the resultant of system of coplanar forces
- finds the resultant of two parallel forces in the same direction and the line of action
- describes the center of gravity using the resultant of parallel forces
- finds the centre of gravity of regular shaped compound bodies.
- find the weight of a body experimentally using the force parallelogram law and verification the law.
- finds the moment of a force and the moment of couple
- explains the motion of a body when the force acts through the centre of mass.
- explains the motion of a body when the force acts away from the center of mass.
- conducts simple activity to find the centre of gravity of a plane object

Suggested learning/teaching process:

- Demonstrate using activities that the result produced by a force depends on the magnitude, the direction and the point of action.
- Explain that the resultant of two or more forces is the single force which produces the same effect(in both magnitude and direction).
- Introduce the principle of parallelogram of forces and derive an equations using the principle to find the magnitude and directions of the resultant of two forces.
- Discuss situation when $\theta = 0°, \theta = 90°, \theta = 180°,$ and two forces are same in magnitude.
- Introduce the force resolution method and force polygon method to find the magnitude and direction of the resultant of a system of coplanar forces.
- Guide students to calculate the resultant force of a given systems of forces.
- Discuss the turning effect of a body due to a force applied and introduce it as the moment of a force.

- Discuss the moment (or torque) produced by a couple of forces and show that the magnitude of the torque of a couple is independent of an axis.
- Guide students to solve problems of moment of forces and to determine the resultant of parallel forces (in same direction) and its line of action.
- Guide students to find the centre of gravity of an irregular shaped laminar using simple activity.
- Introduce centre of gravity of regular shaped uniform bodies such as a rod, a circular laminar, a rectangular laminar, a triangular laminar, ring, a cylinder and a sphere.
- Guide students to determine centre of gravity of regular shaped compound bodies.
- Introduce concept of centre of mass of a body and discuss its relation with centre of gravity.
- Explain the effect of a force acting at centre of mass of an object and away from the centre of mass.
- Explain that the centre of mass of a body cannot be affected by internal forces.

Laboratory practical

Determination of weight of a body using the principle of parallelogram of forces.

Competency level 2.3: **Use Newton's law of motion to analyze the motion of a body**

No. of periods: 20

Learning outcomes :

- states that inertia of a body as the reluctance to change the state of motion.
- realizes mass as a measure of translational inertia.
- introduces gravitational mass as the mass obtained due to the gravitational force.
- states Newton's laws of motion.
- defines force using Newtons 1^{st} law.
- derives *F* = *ma*.
- define the 'newton' as the SI unit of force.
- uses Newton's laws of motion and the concept of momentum to analyze dynamic situations involving constant mass and constant forces.
- uses free body force diagrams to analyze the forces acting on a body and determine the net force
- distinguishes the action force and the reaction force.
- realizes that these forces (action and reaction) always exist .
- realizes that the impulsive force is generally a variable force acting only for a short time.
- gives examples for instances where impulsive forces are used.
- identifies the nature of self adjusting forces.
- analyzes the effects of friction on dynamic systems.
- carries out calculations related to limiting friction and dynamic friction.
- carries out numerical calculations to solve problems using Newton's laws
- describes the states of friction as static friction, limiting friction and dynamic friction.
- carries out calculations related to momentum and its conservation.
- conducts simple activities to demonstrate Newton's laws.

Suggested learning/teaching activities:

- Give examples to explain the concept of inertia.
- Guide students to conduct a simple activity to demonstrate the effect of inertia of a body to change the state of motion.
- Explain that the reluctance to change of state of motion is known as inertia.

- State that the mass of a body is a measure of its inertia.
- Compare the concept of inertial mass and the gravitational mass.
- Use normal gravitational balance to find gravitational mass.
- Explain the difference between inertial frames and non-inertial frames.
- Explain the concept of force using Galileo's inclined plane experiment.
- Explain that a body which is not under acceleration is in a state of dynamic equilibrium.
- Use linear air track to demonstrate,
    - Newton's laws of motion and
    - The principle of conservation of linear momentum.
- Explain Newton's laws of motion.
- Guide students to derive $F=ma$
- Define the 'newton' as the SI unit of force
- Give examples and guide students to conduct activities to understand the nature of action and reaction forces.
- Explain the situations using free body force diagrams.
- Explain the self adjusting forces.
- Explain the friction
    - static friction, limiting friction and dynamic friction
      coefficient of frictions
- Use the laws of friction to explain dynamic and static situations.
- Explain impulse and impulsive forces.
- Assign students to find examples for impulsive forces.

Competency level 2.4: **Manipulates the conditions necessary to keep a body in equilibrium.**

No. of periods: **10**

Learning outcomes :

- conducts activities to identify the conditions for equilibrium of a point object.
- conducts activities to identify the conditions for equilibrium of a rigid object under system of coplanar forces.
- describes the conditions for equilibrium of three parallel coplanar forces.
- describes the conditions for equilibrium of three non parallel coplanar forces.
- express the principle of moments.
- uses the triangle of forces and the principle of moments to solve simple problems related to equilibrium of forces.
- uses force resolution method to solve problems related to equilibrium of forces.
- uses the concepts of equilibrium to stabilize a system.
- identifies three states of equilibrium.
- conducts an experiment to find the weight of a body using the principle of moments.

Suggested learning/teaching activities:

- Guide students to conduct simple activities to demonstrate the necessary conditions for a system of coplanar forces to be in equilibrium.
- Explain the principle of momentum.
- Discuss equilibrium of coplanar forces.
  - explain equilibrium under three non parallel forces
  - explain equilibrium under three parallel forces
  - explain the triangle of forces theorem.
  - explain the polygon of forces
- Guide students to carry out numerical calculations to solve problems.
- Explain the state of equilibrium.
  - stable
  - unstable
  - neutral

Laboratory practical:

Determination of weight of a body using the principle of moments.

Competency level 2.5: **Consumes and transforms mechanical energy productively**.

No. of periods: **15**

Learning outcomes :

- uses the expressions for work done, kinetic energy, potential energy and power to calculate energy changes and efficiencies.
- expresses elastic potential energy in terms of of tension and extension.
- expresses elastic potential energy in terms of force constant and extension
- uses principle of conservation of energy and the principle of conservation of mechanical energy to solve numerical problems.
- states work – energy principle.
- investigates how energy can be used productively.
- recalls and understands the concepts of power and efficiency.
- applies the conservation of energy and conservation of linear momentum in problem solving related to collisions and explosions.
- explains the difference between an elastic collision and inelastic collision.

Suggested learning/teaching activities:

- Explain that if a body moves as a result of a force, the force is said to be doing work on the body.
- State that the work is given by $W = F \times s$ (here W – the work done, F – the constant force and s – the distance moves in the direction of the force).
- State that when the angle between the force and the direction of the motion is θ, the work is given by $W = F\cos\theta \times s$.
- Introduce the concept of energy.
- State that it is convenient to classify energy as being chemical energy or heat energy or nuclear energy etc. there are basically only two types of energy – kinetic energy and potential energy.
- Explain that the energy which a body possesses solely because it is moving is called kinetic energy.
- Explain that the energy which a body possesses due to its position or to the arrangement of its component parts in called potential energy.
- Introduce the expression for gravitational potential energy as $P \cdot E = mgh$

  Here h – the height of the body above some arbitrary reference level.

- Introduce the expressions for elastic potential energy. $W= \frac{1}{2}Fe$ and $W= \frac{1}{2}Ke^2$ when F- external force k- force constant and e - extension
- Explain the conservation of mechanical energy.
- Explain the term "power".
- Give expressions for power

  $P = \frac{w}{t}$ and $P = Fv$

- Guide students to solve problems related to work, energy and power.

Competency level 2.6 : **Rotational motion and circular motion**

No. of periods : **15**

Learning outcomes :

- define angular displacement, angular velocity, and angular acceleration and expresses in SI units.
- relate rpm value and angular velocity.
- relate liner displacement to angular displacement, tangential speed to angular speed and tangential acceleration to angular acceleration.
- describes rotational motion using time period and frequency.
- writes equation of rotational motion
- solve problems using equations of rotational motion.
- explain that the moment of inertia is the measure of rotational inertia.
- expresses moments of inertia of a point mass about an axis as $I = mr^2$
- expresses moment of inertia of a body about an axis as $I = \sum m_i r_i^2$
- demonstrates that moment of inertia depends on mass, axis of rotation and mass distribution.
- relate moment of inertia and angular acceleration to the torque acting on it $\tau = I\alpha$.
- predicts the motion of a rotating body by determining the torque acting on it.
- expresses angular momentum as the product of moments of inertia and angular velocity.
- solves numerical problems associated with moment of inertia, torque and angular momentum.
- gives examples related to principle of conservation of angular momentum.
- conduct simple activities to demonstrate the principle of conservation of angular momentum.
- analyzes situations in which an object moves round a circle at uniform speed.
- calculates the centripetal acceleration of an object moving round a horizontal circular path at a uniform speed.
- identifies centripetal forces of various circular motions.
- relates the centripetal acceleration of such an object to the forces acting on it.
- carries out calculation related to circular motion and rotational motion
- compares angular motion and linear motion.

Suggested learning/teaching activities:

- Conduct a discussion to identify rotational motion.
- Introduce terms related to rotational motion.
    - angular displacement
    - angular velocity
    - angular acceleration
    - time period
    - frequency
- Give relationships $T = \frac{2\pi}{\omega}$ $\omega = 2\pi f$
- Introduce the relationships between angular motion and linear motion.
  $s = r\theta$, $v = r\omega$, $a = r\alpha$
- Introduce equations of rotational motion under constant angular acceleration.
- $\omega=\omega_0+\alpha t$, $\omega^2=\omega_0^2+2\alpha\theta$, $\theta=\omega_0 t+\frac{1}{2}\alpha t^2$, $\theta=\left(\frac{\omega+\omega_0}{2}\right)t$
- Guide students to solve simple problems.
- Introduce moment of inertia is a measure of inertia for rotational motion.
- Explan that the moment of inertia of a point object about an axis *as*
  $I = mr^2$
- Explain that the moment of inertia of a mass distribution is given by $I = \sum m_i r_i^2$ where r_i is the perpendicular distance from the axis of a particle of mass m_i.
- Guide students to conduct activities to demonstrate the effect of the mass distribution and axis of rotation on the moment of inertia.
- Explain the moment of inertia depends on the mass of the body, its size, its shape and which axis is being considered.
- Give moment of inertia of a uniform rod, ring, disk, cylinder, sphere.
- Recall, in linear motion a force produces an acceleration which is related to the force through Newton's second law.
- Explain that, in rotational motion a torque gives rise to an angular acceleration and relates torque and angular acceleration as $\tau = I\alpha$
  where τ = the applied torque
  I = the moment of inertia
  α = the angular acceleration of the body
- Introduce angular momentum as the product of moment of inertia and angular velocity $L = I\omega$
- State the principle of conservation of angular momentum.

- Discuss that the conservation of both magnitude and the direction of angular momentum using examples.
- Conduct simple activities to demonstrate the conservation of angular momentum.
- Give the expression for work done by a torque as $W = \tau\theta$
- Give the expression for rotational kinetic energy as $K \cdot E = \frac{1}{2} I\omega^2$
- Give the expression for power as $P = \tau\omega$
- explain circular motion using day to day example.
- Introduce terms related to circular motion and rotational motion
- Introduce centripetal acceleration and give expressions for it
- Explain the uniform circular motion of a particle in a horizontal plane.
- Assign students to identify centripetal forces of various circular motions.

Competency level 2.7: **Hydrostatic pressure**

No. of periods: 14

Learning outcomes :

- solves problems relating to comparison of densities with Hare's apparatus and U-tube.
- applies Pascal's principle to solve problems and to explain the working principle of hydraulic systems.
- uses Archimedes' principle and principle of floatation to solve problems and to explain phenomena relating to sinking and floating.
- verifies Archimedes principle theoretically and practically
- compares densities of liquids using U.Tube and Hares apparatus
- finds the density of a liquid using hydrometer

Suggested learning/teaching activities:

- Recall the definitions of density and relative density.
- Introduce homogeneous and incompressible fluids.
- Derive the expression $p = h\rho g$ for hydrostatic pressure at a point in a homogeneous liquid at rest.
- Explain that the pressure in a fluid increases with depth. All points at the same depth in the fluid are at the same pressure.
- Explain that the force perpendicular to the surface is independent of the orientation of the surface.
- State that the pressure in a liquid acts equally in all directions.
- Explain the comparison of densities of two liquids using a U tube and hare's apparatus.
- State Pascal's principle.
- Explain how a force can be increased using hydraulic pressure, apparatus.
- Conduct a discussion to identify the uses of Pascal's principle.
- Recall upthrust exerts on a body immerse in a liquid.
- State Archimedes's principle
- Guide students to verify the Archimedes's principle theoretically.
- Conduct simple activity to verify the Archimedes principle practically.
- State the principle of flotation.
- Discuss the conditions for flotation.
- Introduce centre of Buoyancy.
- Describe the structure of hydrometer.
- Explain the use of hydrometer.
- Guide students to compare densities of various liquids using hydrometer.

Laboratory experiments

- Comparison of densities using U tube.
- Comparison of densities using hare's apparatus.
- Determination of density of a liquid using weighted test tube.

Competency level 2.8: **Fluid dynamics**

No. of periods: 08

Learning outcomes :

- distinguishes between streamline and turbulent flow.
- uses the equation of continuity for a steady streamline flow.
- states the conditions under which Bernoulli's principle is valid.
- applies Bernoulli's principle to solve problems.
- conducts simple activities to demonstrate Bernolli's principle.

Suggested learning/teaching activities:

- Explain following terms related to fluid flow.
  - Steady flow
    If the flow of a fluid is steady, then all the fluid particles that pass any given point follow the same path at the same speed.
  - Turbulent flow
    In this type of flow the speed and direction of the fluid particles passing any point vary with time.
  - Line of flow
    The path followed by a particle of the fluid
  - Streamline
    A streamline is a curve whose tangent at any point is along the direction of the velocity of the fluid particles at that point. Streamline never cross.In steady flow the streamlines coincide with lines of flow.
- Tube of flow
  This is a tabular region of a flowing fluid whose boundaries are defined by a set of streamlines.
- Incompressible fluid
  This is a fluid in which changes in pressure produce no change in the density of the fluid.
  Liquids can be considered to be incompressible and gases subject only to small pressure differences can also be taken to be incompressible.
- Present the equation of continuity.
- Present Bernoulli's equation and the conditions for validity.
- Discuss applications of Bernoulli's equation.
- Explain phenomena that can be explained using Bernoulli's equation.
- Guide students to solve problems related to fluid dynamics.

Unit 3 : Oscillations and Waves

Competency Level 3.1: **Analyze oscillations on the basis of physics.**

No of Periods: 15

Learning outcomes :

- describes the conditions necessary for simple harmonic motion.
- defines simple harmonic motion.
- recognizes and uses $a = -\omega^2 x$ as the characteristic equation of simple harmonic motion.
- relates the motion of an oscillating object to the forces acting on it.
- explains amplitude, frequency and period of a simple harmonic motion.
- describes the interchange between kinetic and potential energy during simple harmonic motion.
- illustrates the S.H.M. as a projection of a circular motion.
- Introduce phase angle.
- identifies the state of the motion of a particle in S.H.M. using the phase.
- uses phase difference to illustrate of motion of two S.H.M.s
- finds the displacement of an oscillating particle starting from center position. ($x = A$ Sin ω t)
- uses the displacement – time graph of the particle to explain the S.H.M.
- explain the variations of displacement, velocity and acceleration of a S.H.M using graphical representations.
- determines the gravitational acceleration using simple pendulum
- determines the spring constant of a light helical spring
- distinguishes free, damped and forced oscillations.
- demonstrates forced oscillations and resonance using Barton's pendulum.
- give practical examples of forced oscillations and resonance.
- investigate that there are some instances in which resonance is useful and other instances in which resonance should be avoided.

Suggested learning/teaching activities :

- Guide students to observe an oscillatory system such as a simple pendulum or a loaded spring to explain and define displacement, amplitude, period and frequency of oscillation.
- Describe S. H. M. considering the variation of displacement, velocity, acceleration and energy transformation.
- Explain and introduce simple harmonic motion as an oscillatory motion with a special property satisfying the relation $a = -\omega^2 x$

- Define simple harmonic motion.
- Show that S.H.M. can be represented as a projection of a uniform circular motion and discuss the usefulness of this representation.
- Deduce $a_{\max} = -\omega^2 A$ using the above representation or otherwise and hence introduce relations $f = \frac{1}{T}$, $\omega = 2\pi f$, $v_{\max} = A\omega$
- Introduce the phase (angle) of oscillation and hence phase difference (eg. Using two simple pendulums)
- Introduce the displacement – time graph of S.H.M. and explain the nature of S.H.M. using it.
- Introduce velocity vs. time and acceleration vs. time graphs for a S. H. M.
- Give expressions for the time period of a simple pendulum and mass suspended by a light helical spring.
- Explain free oscillation and damped oscillations
- Use Barton's pendulums to demonstrate forced oscillations and resonance.
- Assign students to give examples of uses and disadvantages of resonance.

Laboratory practical

- Determination of acceleration due to gravity using simple pendulum
- Determination of the relationship between the suspended mass and the period of oscillation of light-helical spring

Competency Level 3.2: **Investigates various types of wave motion and their uses**.

No of Periods : 08

Learning outcomes :

- demonstrates wave motion using slinky
- describes wave motion in terms of S.H.M. of particles.
- distinguishes between longitudinal and transverse waves.
- represents the wave motion graphically and identify points in same phase (in phase) and different phase (out of phase).
- identifies wavelength using points of the same phase.
- deduce $v = f\lambda$ from the definitions of speed, frequency and wavelength
- solves problems related to wave motion.

Suggested learning/teaching activities :

- Explain that wave motion occurs due to the disturbance of particles in a medium by a source.
- Use simple activities or computer simulations to demonstrate the wave motion. Hence explain followings
  - Propagation of energy in wave motion
  - Wave motion without the propagation of matter.
  - All the particles in the direction of wave motion oscillate with same frequency and with same amplitude if there is no energy loss
  - Particles in the direction of wave motion oscillate with different phases
- Explain that there are two types of wave motions as transverse and longitudinal waves according to the direction of oscillation of particles.
- Assign students to give examples for those two types of waves.
- Introduce the graphical representation of wave motion i.e. the positions of all particles in the direction of wave propagation at one instant.
- Explain following terms using graphical representation.
  - Points of same phase (in phase)
  - out of phase
  - phase difference of points
  - crests
  - trough
  - wavelength

- frequency
- time period.

- Explain that the maximum displacement of a point in a wave is known as the Amplitude of the wave.
- The state of motion (for instant speed and direction) of a particle on the wave is known as the phase of that wave and is represented by the symbol θ and θ is known as the phase angle.
- The number of cycles created by a wave in a unit time is known as frequency f of that wave. The relationship between period of oscillation T and frequency f is given by $f = \frac{1}{T}$.
- Introduce the terms "in phase" and "out of phase" by explaining phases of two different points of a wave with the aid of a wave diagram. Explain that phase difference between two consecutive points in phase is 2π rad and that phase difference between two consecutive points out of phase is π rad.
- Define wave length λ as the distance between two consecutive points of a wave which are in the same phase.
- Using the fact that the displacement of a wave in a unit time is the velocity v, deduce that $v = f\lambda$.
- Suitable simple calculations should be given to the students for the clear understanding of the above principles and concepts

Competency Level 3.3 **Investigates the uses of waves on the basis of their properties**.

No of Periods: 15

Learning outcomes :

- conducts simple activities to demonstrate the properties of waves by using ripple tank and a string/ slinky
- states reflection, refraction, interference and diffraction as common properties of waves.
- demonstrate rigid reflection and soft reflection through simple activities.
- distinguishes rigid reflection and soft reflection.
- describes change of velocity, wavelength and direction in different media to describe the effects of refraction.
- defines refractive index.
- relate, refractive index with speed , wave length and angle of incidence and angle of refraction.

  $$n_2 = \frac{V_1}{V_2} = \frac{\lambda_1}{\lambda_2} = \frac{\sin i}{\sin r}$$

- carries out numerical calculations on refraction.
- states the principle of superposition of waves.
- graphically represents the principle of superposition of waves.
- uses the principle of superposition of waves to explain the occurrence of interference, stationary waves and beats qualitatively.
- demonstrates stationary waves using string vibrator.
- states conditions to be satisfied to produce stationary waves.
- represents stationary waves graphically.
- comperes stationary waves and progressive waves
- demonstrates beats using CRO and tuning forks.
- carries out numerical calculations on beats and stationary waves.
- explains diffraction, interference and polarization qualitatively.

Suggested learning/teaching activities :

- Produce plane wave fronts in a ripple tank and observe the reflection of waves using a metal plate show that reflections occur in accordance with laws of reflection.
- Rigid reflection
  - Explain what is meant by a rigid surface.
    - Keep a slinky horizontally on a table and fix one end firmly to stand. At the other end of the slinky make a single pulse parallel to the surface of the table, observe reflections.

        - In rigid reflection, phase of the pulse change by π rad.
        - Explain that a wave is a consecutive series of pulses and draw wave diagrams to show rigid reflection (incident wave and reflected wave)
- Soft reflection
    - Explain the term soft reflection.
    - Keep a slinky horizontally on the table. Pull one end of the slinky parallel to the surface of the table while keeping the other end free. Observe the reflection.
    - Show that a phase change does not occur during pulse reflection with the aid of diagrams show how the incident and reflection waves occur during soft reflection.
- Explain that a resultant wave is produced by incident and reflection waves and hence waves produced by soft reflection and rigid reflection cannot be observed practically.
- Stress the following properties of wave reflection.
    - Reflection occur according to laws of reflection.
    - Frequency, wave length and velocity of waves do not change during reflection of waves.
    - If reflecting surface is rigid the phase change π occur during reflection.
    - If the reflecting surface is soft phase change does not occur during reflection.
- Refraction of a wave
    - Demonstrate the refraction of plane wave fronts using a ripple tank.
    - Explain that wave refraction occurs when waves enter at an angle from one medium to another medium with a different velocity.
    - Define Refractive Index of refractive medium with respect to incident medium as,

      $\dfrac{\text{velocity of incident medium } v_1}{\text{velocity of refractive medium } v_2}$ state that frequency f does not change during refraction and show,

      $${}_1n_2 = \frac{V_1}{V_2} = \frac{\lambda_1}{\lambda_2} = \frac{\sin i}{\sin r}$$
- Diffraction of a wave
    - Carry out activities to observe diffraction of water waves in a ripple tank.

- Discuss the characteristics of the diffracted waves in terms of wave length, frequency, speed, direction of propagation and shape of waves in relation to the incident.
    - Demonstrate that diffraction occurs when waves go through the slit.
    - Discuss the effect of size of the slit and wave length of the wave on diffraction.
- Interference of a wave
    - State and discuss the principle of superposition.
    - Carry out activities to observe interference patterns of water waves in a ripple tank.
    - Discuss constructive and destructive interference using diagrams.
    - Use a vibrator to set a thin string in vibration and demonstrate stationary waves.
    - Show and explain with diagrams how stationary waves occur when there is rigid reflection.
    - Explain the conditions necessary for the production of a stationary wave.
    - Describe graphically the formation of stationary waves.
    - Distinguish the properties of stationary and progressive waves.
    - Demonstrate the formation of nodes and antinodes during the above activities.
    - Predict and locate experimentally the nodes and antinodes using a microphone, AF signal generator and CRO.
- Beats produced by waves
    - Select two turning forks with the same frequency and apply a little wax on one of them, sound them at the same time and observe beats.
    - Illustrate graphically the occurrence of beats of near frequencies.
    - Introduce the equation :-

$$\left[f_b = \left| f_1 - f_2 \right| \right]$$

- Polarization of a wave
- Demonstrate the vibration plane of transverse waves by showing the plane of waves of a string.
- The fact that vibration of a wave could be confined to a single plane is called polarization. That plane is called plane of polarization.
- Demonstrate using a slinky that polarization occurs only in transverse waves and not in longitudinal waves.
- By observation of polarization arrive at the conclusion that sound waves are longitudinal waves. and light waves are transverse waves

Competency Level 3.4: **Uses the modes of vibration of strings by manipulating variables**

No of Periods: 12

Learning outcomes :

- gives the expression for the speed of transverse waves in terms of the tension and the liner density.
- explains the numerical patterns of resonant frequencies for stationary waves on strings.
- identifies fundamental mode, overtones and harmonic.
- derives expressions for the frequencies of fundamental mode and overtones .
- carries out calculations on stationary wave patterns on strings.
- finds the frequency of a tuning fork using sonometer.
- investigates experimentally the relationship between the vibrating length and the frequency.
- gives the expression for the speed of longitudinal waves in terms of elastic modules and density.
- describes seismic waves, Earth quakes, Richter scale and formation of tsunami qualitatively.
- prepares a report to explain earthquake and Tsunami

Suggested learning/teaching activities :

- Guide students to carry out an experiment to observe stationary waves in a stretched string.
- Use the above experiment to draw and show the fundamental wave pattern and the other forms of wave patterns of stationary waves in a stretched string.
- Explain with the aid of diagrams how to find wave length of the wave and explain how to calculate the frequency of the wave using $v = f\lambda$
- Show the stationary wave modes form in a string vibrating freely and describe how to name them as fundamental, overtone and harmonics.
- State that the speed of a transverse wave in stretched string is given by $v = \sqrt{\frac{T}{m}}$ where T is the tension of the string and m is the mass of a unit length of the string.
- Deduce by using $v = f\lambda$ and $v = \sqrt{\frac{T}{m}}$ that the frequency of the fundamental mode of a string of length l is,

$$f_0 = \frac{1}{2l}\sqrt{\frac{T}{m}}$$

- Give the equation, frequency f_n of the n^{th} overtone is,

$$f_n = \frac{n+1}{2l}\sqrt{\frac{T}{m}}$$

- Uses of the sonometer
    - Explain how to find the frequency of a tuning folk by varying the tension of the sonometer wire.
    - Explain the method to find out the relationship between frequency of a stretched string and the length of the string.
- State that the velocity v of longitudinal waves in a solid medium is $v = \sqrt{\frac{E}{\rho}}$ where E is the elastic modulus of the medium and the ρ is the density of the medium
- Calculate the speed of longitudinal waves in a rod.
- Introduce qualitatively the seismic waves produced during earthquakes.
    - Body waves as P waves and S waves.
    - Surface waves
    - Ritcher scale.
- Discuss briefly Tsunami and the factors causing a Tsunami.
- Characteristics of a Tsunami and the disaster caused by it.
- Guide students to solve simple problems for better understanding of the above relationships.

Laboratory practical

- Determine the frequency of a tuning folk using a sonometer by changing the tension of the string.
- Verification of the relationship between vibrating length and frequency by a graphical method, using a set of tuning folks.

Competency Level 3.5: **Inquires about propagation of sound in gaseous media and uses vibrations in air columns by manipulating the variables.**

No of Periods: 10

Learning outcomes :

- gives the expression for the speed of wave in air.
- deduses $v = \sqrt{\frac{\gamma RT}{M}}$
- describe the effect of pressure, temperature, molar mass and humidity on the speed of sound in air.
- describes the formation of stationary waves open tube and close tube.
- explains the numerical patterns of resonant frequencies of harmonics for stationary waves in one end close tube and open tubes.
- obtains expression for the fundamental and overtone frequencies in a resonance tube.
- designs experiments to determine the speed of sound in air and the end correction of the tube using one tuning fork.
- designs experiments to determine the speed of sound in air and the end correction of the tube using set of tuning forks.
- carries out calculations on stationary waves in resonant tubes

Suggested learning/teaching activities :

- Explain that sound travels essentially in a medium as a longitudinal wave when the wave is set up by a vibration in the medium.
- State that the speed of a sound wave in a gas is given by $v = \sqrt{\frac{\gamma P}{\rho}}$
- Use the ideal gas equation to change the above equation to the form $v = \sqrt{\frac{\gamma RT}{M}}$
- Explain with the help of the above equation that the speed of sound in a gas is dependent on the temperature but is independent of the pressure.
- Explain that the speed of sound in a gas also depends on the composition of the gas such as the presence of water vapor or humidity.
- State that $v \propto \sqrt{T}$ for a given gas and give the relationship $\frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}}$
- State that $v \propto \frac{1}{\sqrt{M}}$ for gases in same temperature and give the relationship $\frac{v_1}{v_2} = \sqrt{\frac{M_2}{M_1}}$

- Guide students to solve problems related to speed of sound in gases.
- Explain how to set up vibrations in air columns in open pipes (tubes) and also in pipes (tubes) closed at one end.
- Explain that the stationary waves are formed due to superposition of the incident and reflected waves.
- Illustrate graphically the wave patterns of various modes of vibration such as the fundamental, overtones or harmonics, locating the nodes and antinodes.
- Use relative positions of nodes and anti-nodes to derive the relationship between the wave length and the length of the pipe.
- Explain the existence of the end correction of the pipe '
- Guide students to solve problems and also perform experiments involving vibrations of air columns in pipes.

Laboratory experiments

- Determination of the speed of sound in air using a closed resonance pipe (tube)
    - With one turning fork
    - With a set of turning forks (graphical method)

Competency Level 3.6: **Inquires about the phenomenon of Doppler effect and its application**.

No of Periods: 05

Learning outcomes :

- conducts simple activities to demonstrate the Doppler effect.
- derives expression for the apparent frequency, considering the change of wave length due to the motion of the soure .
- derives expressions for the apparent frequency considering relative speed of sound due to the motion of the observer
- deduces an expressions for the apparent frequency of the souce and the observer are moving
- describes phenomena related to change in apparent frequency using Doppler effect
- applies the Doppler effect to sound with appropriate Calculations
- Describes how shock wave is formed.
- explains the applications and explanations related to Doppler effect.

Suggested learning/teaching activities :

- Explain occurrence of Doppler effect using examples such as the variation of frequency of the horn of a moving train as heard by an observer standing close to the railway track.
- Explain using illustrations the variation of the frequency heard by the stationary observer when the source approaches, passes and moves away from him.
- Explain also using illustrations the variations of frequency heard by the observer when he approaches and then leaves the source while traveling in a vehicle.
- Explain using illustrations the variations of frequency as heard by the observer when both the observer and source are moving.
- Assign students to demonstrate Doppler effect using two identical turning forks fixed to two wooden boxes. Vibrate both, move one towards the wall keeping the other fixed. Hear beats.
- Derive expressions for apparent frequency relevant to different situations of relative motion between the source of sound and the observer.
- Guide students to solve problems involving Doppler effect.
- Mention applications of Doppler effect in practical situations.
- Explain using diagrams that the speed of the source approaches the speed of sound in a medium, the wave begin to bunch up closer and closure.

- Show that the speed of the source exceeds the speed of sound , a V – shaped bow wave is formed.
- explain that, in air, when a jet air craft travels at a supersonic speed, a bow wave in the form of a conical shock wave that trail out and down ward from the air craft.
- State, when this high – pressure, compressed wave form passes over an observer, a sonic boom in heard.
- Assign students to find examples of explanations and applications of Doppler effect.

Competency Level 3.7: **produces and propagates sound by considering characteristics of sound.**

No of Periods: 05

Learning outcomes :

- describes the characteristic properties of sound.
- uses the graph of intensity level verses the frequency for human ear to explain various situations.
- conducts activities to demonstrate characteristics of sound
- carries out numerical calculations related to intensity level (decibel) and intensity
- introduces ultrasonic and infrasonic qualitatively.
- uses the knowledge of properties of sound in day-to-day activities
- explains the importance of having proper sound levels.

Suggested learning/teaching activities :

- Introduce and explain characteristic properties of sound
- Carry out activities to observe the effect of
  - amplitude on loudness
  - frequency on pitch
- Use the CRO and various musical instruments to demonstrate the quality of sound
- Explain the reasons that effects the quality of sound
- Explain the threshold of hearing and the threshold of pain for human ear and give relevant values of sound intensity
- Define decibel as the unit for measuring the intensity level of sound
- Discuss and instruct to solve problems involving intensity level of sound
- Assign students to explore and report about sound pollution.

Competency Level 3.8: **Inquires about electromagnetic waves.**

No of Periods: 05

Learning outcomes :

- state that electro magnetic waves consist of oscillating of electric and magnetic fields.
- states that electromagnetic waves generate due to the acceleration or deceleration of charge particles.
- represents electromagnetic waves graphically.
- categorizes electromagnetic waves using electromagnetic spectrum.
- describes the properties of electromagnetic waves
- describes the applications of electromagnetic waves in each of the main wavelength ranges
- explains the principle of LASER
- identifies the properties and uses of LASER beams.

Suggested learning/teaching activities :

- Explain with the aid of diagrams that electromagnetic waves are propagated by electric field(E) and a magnetic field(B) which are oscillating at right angles to each other.
- State that the ratio between the amplitudes of these oscillations is equal to the velocity of the wave.
  $\frac{E}{B} = C$ where C is velocity of electromagnetic wave.
- State that velocity of electromagnetic waves in a vaccum is $3 \times 10^{8} \mathrm{ms}^{-1}$ $(2.99792458\mathrm{ms}^{-1})$ and that a medium is not required for the propagation of electromagnetic waves.
- The velocity of electromagnetic waves will reduce when propagated through a medium.
- Experiments show that the electric field is responsible for many functions of electromagnetic waves. (Exposure to photographic films, Fluorescence etc.). Hence the plane of vibration of electromagnetic waves is accepted as the plane of vibration of electric field.(E)
- Explain that electromagnetic waves are transverse waves since they can be confined to one plane(can be polarized) under experimental conditions.
- State that vibrations can occur in all the planes according to the method of generation of electromagnetic waves.
- State that plane polarized waves could be obtained by filtering through a plane polarizing filter or by using a transmitting antenna.

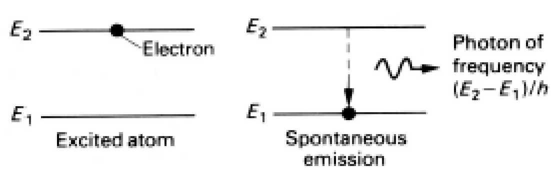
- Discuss briefly the instances where electromagnetic waves produced naturally and artificially (Lightening - electrical sparks, electrical discharges - produced under low pressure conditions, atomic vibrations, electronic oscillators, nuclear reactions etc.)
- Show how the electromagnetic spectrum is distributed according to wavelength λ and frequency f.
  Name the wave bands :- Radio waves, VHF, UHF(microwaves), IR, visible light , UV, X-rays and γ - rays.
- State briefly the characteristics and the uses of each wave band.

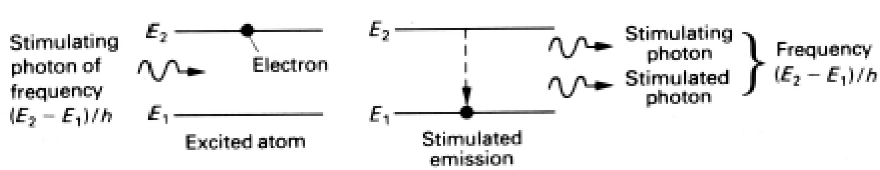
Lasers

The term LASER is an acronym for Light Amplification by Stimulated Emission of Radiation. The first laser was constructed in 1960.

(a) Action.
(b) The action of a laser can be explained in terms of energy levels.

A material whose atoms are excited emits radiation when electrons in higher energy levels return to lower levels. Normally this occurs randomly, i.e. spontaneous emission occurs, Figure 3.6 ., and the radiation is emitted in all directions and is incoherent. The emission of light from ordinary sources is due to this process. However, if a photon of exactly the correct energy approaches an excited atom, an electron in a higher energy level may be induced to fall to a lower level and emit another photon. The remarkable fact is that this photon has the same phase. frequency and direction of travel as the stimulating photon which is itself unaffected. This phenomenon was predicted by Einstein and is called stimulated emission; it is illustrated in Figure 3.7.,





In a laser it is arranged that light emission by stimulated emission exceeds that by spontaneous emission. To achieve this it is necessary to have more electrons in an upper than a lower level. Such a condition, called an inverted population" is the reverse of the normal state to affairs but it is essential for light amplification, i.e for a beam of light to increase in intensity as it passes through a material rather than to decrease as is usually the case.

One method of creating an inverted population is known as ' optical pumping" and consists of illumination the laser material with light. Consider two levels of energies E_1 and E_2 where $E_2 > E_1$. If the pumping radiation contains photons of frequency $(E_2-E_1)/h$, electrons will be raised from level 1 to level 2 by photon absorption. Unfortunately, however. as soon as the electron population in level 2 stats to increase, the pumping radiation induces stimulated emission from level 2 to level 1, since it is of the correct frequency and no build up occurs.

In a three level system. Figure 3.8., the pumping radiation of frequency $(E_3-E_1)/h$, raises electrons from level 1 to level 3, from which they fall by spontaneous emission to level 2. An inverted population can arise between level 2 and 1 if electrons remain long enough in level 2. The spontaneous emission of a photon due to an electronic fall from level 2 to level 1 may subsequently cause the stimulated emission of a photon which in turn releases more photons from other atoms. The laser action thus occurs between level 2 and 1 and the pumping radiation has different frequency from that of the stimulated radiation.

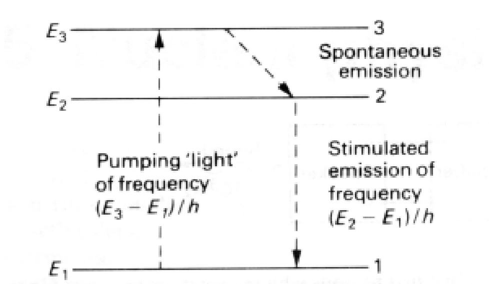


Figure 3.8 Action of laser in a three level system

Competency Level 3.9 Applies the principles of refraction of light for daily pursuits

No of Periods: 15

Learning outcomes :

- designs activities to determine images formed due to refraction.
- state laws of refraction.
- define absolute and relative refractive indices.
- obtains the relationship between real depth and apparent depth.
- obtains the relationship for apparent displacement.
- carries out calculations to solve problem related to apparent displacement.
- finds the refractive index of glass using travelling microscope.
- describes critical angle and total internal reflection.
- carries out calculations on refraction at plane boundaries and total internal reflection.
- deduces the relationship between critical angle and refractive index.
- designs an experiment to find the refractive index using critical angle method.
- draws a ray diagram for a ray through a prism .
- describes the refraction for a ray through a prism .
- conducts an experiment to investigate the variation of derivation with the angle of incidence.
- introduces the angle of minimum derivation
- derives the relationship between prism angle, refractive index and the angel of minimum deviation
- carries out three main adjustment of the spectrometer.
- uses spectrometer to find the angle of minimum deviation and the angle of a prism.
- find the images formed by lenses using no parallax method
- constructs images formed by lenses using ray diagrams
- derives lens formula by geometrical method using Cartesian sign convention.
- define linear magnification.
- obtains expression for linear magnification
- define power of a lens.
- uses the expression for the focal length of a thin lens combination in contact.
- carries out numerical calculations to solve problems for lenses and lens combination

- uses the power of a lens as Converging(+), Diverging(-)
- conducts experimentation to determine the focal length of convex lenses and concave lenses

Suggested learning/teaching activities :

- Explain the phenomenon of refraction, condition for refraction and the laws of refraction.
- Define refractive index (absolute and relative) and deduce expressions for the relationships between refractive indices.
- Carry out activities to demonstrate apparent depth and derive expression for apparent depth and apparent displacement in relation to refractive index. $\left(n = \frac{real\ depth}{apparent\ depth}\right), d = t\left(1 - \frac{1}{n}\right)$
- Explain the phenomenon of total internal reflection using ray diagrams and introduce the critical angle.
- Derive expression $n = \frac{1}{\sin\ C}$ and assign problems on total internal reflection and critical angle to solve.
- Explain refraction of light through a prism using ray diagrams and obtain geometrical relations connecting the angles of incidence, refraction, emergence and deviation.
- Guide students to study the variation of the angle of deviation with the angle of incidence experimentally and interpret graphically to understand the angle of minimum deviation.
- Explain qualitatively dispersion of light.
- Demonstrate the main adjustments of the spectrometer giving reasons and hence determine the angle of the prism and the angle of minimum deviation of the prism.
- Introduce applications of total internal reflection.
- Introduce dispersion qualitatively
- Explain refraction through thin lenses with the introduction of the foci and focal length and direct students to construct images using ray diagrams.
- Derive using a geometrical method the lens formula in relevance with the Cartesian sign connection.
- Assign students to investigate the characteristics of real and virtual images –

Algebraically (using formula)

Geometrically (using ray diagrams) and experimentally

- Assign problems on lens formula and guide students to solve them, guiding students for the correct application of the sign connections.
- Introduce the equation for the thin lens combination in contact and carry out calculations involving the formula

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

- Guide students to perform given experiment on prisms and lenses and evaluate the results.

Laboratory experiments

- Determination of the refractive index of glass using a rectangular glass block and a travelling microscope.
- Experimental investigation of deviation of light through a glass prism and hence determination of the angle of minimum deviation graphically.
- Determination of refractive index of a prism by the critical angle method.
- Experiments using the spectrometer
  - main adjustments
  - determination of the angle of a prism
  - determination of the angle of minimum deviation of a prism
- Determination of focal length of convex lenses and concave lenses.

Competency Level 3.10: **Applies the knowledge of images formed by the lenses to understand the function of the human eye and hence use the same for correction of the defects of vision**

No of Periods: 04

Learning outcomes :

- describes optical system of human eye.
- explains the formation of image on eye.
- describes near point ,far point and least distance of distinct vision .
- introduced visual angle.
- describes defects of vision and sight corrections using ray diagrams.
- carries out sight correction calculations.
- describes Presbyopia qualitatively.

Suggested learning/teaching activities :

- Introduce visual angle using ray diagrams
- Introduce the main features of the eye using a diagram and explain the functions of the components
- Introduce the range of distinct vision of the eye and hence describe the defect of vision such as short sight and long sight using ray diagrams
- Explain the optical methods of correcting the defects of vision and guide the students to carry out appropriate calculations
- Explain briefly defects of vision such as pres-byopia.

Competency Level 3.11 **Uses the knowledge of the images formed by lenses to explain the actions of optical instruments and hence in using the appropriately**

No of Periods 06

Learning outcomes :

- uses of simple/ compound microscope and astronomical telescope properly.
- defines magnifying power (angular magnification) of microscope and telescope in normal adjustment
- sketches ray diagrams to explain how a simple and compound microscope work and carry out related calculations.
- sketches ray diagrams to explain how astronomical telescopes work

Suggested learning/teaching activities :

- Introduce angular magnification of optical instruments.
- Assign students to use a converging lens as a magnifying glass.
- Explain the simple microscope using a ray diagram and derive an expression for its angular magnification in normal adjustment.
- Explain the compound microscope using a ray diagram and derive an expression for its angular magnification in normal adjustment.
- Guide students to perform calculations involving microscopes.
- Explain the astronomical telescope using a ray diagram and derive an expression for its angular magnification in normal adjustment.
- Discuss instances where microscopes and telescopes are not in normal adjustment such as when,
  1. The final image of a microscope is at the far point, and,
  2. The final image of a telescope is at the near point
- Assign problems on microscopes and telescopes to students and guide them to solve the problem.

Unit 4: Thermal physics

Competency Level 4.1: **Measures temperature correctly by selecting and appropriate thermometer according to the need.**

No of Periods: 08

Learning outcomes :

- states that heat is transferred from a region of higher temperature to a region of lower temperature.
- states zeroth law of thermodynamics
- understands that regions of equal temperature are in thermal equilibrium.
- states thermometric properties and gives examples for thermometric properties
- states fixed points of temperature scale.
- understands that there is an absolute scale of temperature that does not depend on the property of any particular substance (i.e. the thermodynamic scale and the concept of absolute zero)
- states expression for temperature based on two fixed points.
- states triple point of water.
- states expression for absolute temperature based on triple point of water.
- relates and uses Kelvin and Celsius temperature scales.
- carries out numerical calculations to solve problems related to expression of temperature.
- explains uses of mercury/alcohol in glass thermometers.

Suggested learning-teaching process:

- Explain that heat flows from a region at higher temperature to a region at lower temperatures.
- Explain the state of thermal equilibrium.
- State the zeroth law of thermodynamics and explain it.
- Discuss thermometric properties with example.
- Obtain the expression for temperature based on two fixed points

  $$\theta = \left(\frac{X_\theta - X_L}{X_H - X_L}\right)(\theta_H - \theta_L) + \theta_L$$

- Describe the Celsius scale and show that $\theta = \left(\frac{X_\theta - X_L}{X_H - X_L}\right) \times 100$
- Introduce absolute zero and the triple point of water.

- Obtain the expression for absolute temperature (measured in Kelvin) based on the triple point of water, $T = \left(\frac{X_T}{X_{tr}}\right)273.16$
- Obtain the relationship between Celsius and Kelvin temperature scales, $T = \theta + 273.15$
- Describe the mercury-in-glass thermometer
- Describe the thermocouple qualitatively
- Carry out calculations related to temperature scales

Competency Level 4.2: **Inquires about the instances where the expansion of solids and liquids are used.**

No of Periods: 06

Learning outcomes :

- explains heat expansion.
- defines linear area and volume expansivities.
- states expression for linear, area and volume expansion.
- expresses relationship between linear, area and volume expansivities.
- defines real expansion of liquid.
- defines apparent expansion of liquid.
- Introduces relationship between γ_{real} , $\gamma_{apparent}$ and α.
- carries out numerical calculations to solve problems related to thermal expansion of solids and liquids.
- explains the variation of density of liquids due to thermal expansion of liquids.
- explains phenomena related to anomalous expansion of water.
- uses the knowledge of expansion of solids and liquids in day to day activities.
- gives examples for uses and disadvantages of solids and liquids.

Suggested learning-teaching process

- Explain the expansion of solids in terms of molecular vibration
- Introduce linear expansion and define linear expansivity (α)
- Obtain the relationship $l_2 = l_1(1+\alpha\Delta\theta)$ using the definition of α
- Introduce area expansion and define area expansivity (β)
- Obtain the relationship $A_2 = A_1(1+\beta\Delta\theta)$ and show that $\beta = 2\alpha$
- Introduce volume expansion and define volume expansivity (γ)
- Obtain the relationship $V_2 = V_1(1+\gamma\Delta\theta)$ and show that $\gamma = 3\alpha$
- Explain apparent expansion and real expansion of liquid
- Guide students to carry out simple activities to show that real *expansion = apparent expansion + expansion of the container*
- Introduce the equation $\gamma_{real} = \gamma_{aparent} + 3\alpha$
- Derive the relationship $\rho_{\theta_2} = \dfrac{\rho_{\theta_1}}{1+\gamma(\theta_2-\theta_1)}$
- Explain the anomalous expansion of water with the aid of a graph of volume vs. temperature for a fixed mass of water.

- Present the graph density of water vs. temperature.
- Explain that maximum density of water exists at $4^0 C$ where its volume is minimum.
- Discuss the uses of expansion of solids and liquids
- Guide students to solve problems related to expansion.

Competency Level 4.3 **Investigates the behavior of gases using gas laws**

No. of periods: 10

Learning outcomes :

- express the Boyle's law.
- determines the atmospheric pressure using Boyle's law (quill tube)
- investigate relationship between volume and temperature at constant pressure.
- express the Charle's law.
- investigates relationship between pressure and temperature at constant volume.
- express the pressure law.
- derives combine gas equation
- derives the ideal gas equation, $pV = nRT$
- uses gas laws to explain the behavior of gases.
- analyzes the behavior of gases using ideal gas equation.
- express Dolton's law of partial pressure.
- carries out numerical calculations to solve problems using gas laws.

Suggested learning-teaching activities

- Conduct a discussion regarding behavior of gases highlighting pressure, volume and temperature of a fixed mass of a gas as the variables to be considered.
- Explain the relationship between pressure and volume of a fixed mass of a gas at constant temperature and call it as Boyle's law.
- Explain relationship between volume and temperature of a fixed mass of a gas at constant pressure and call it as Charles's law.
- Explain the relationship between pressure and temperature of a fixed mass of a gas at constant volume and call it as pressure law.
- Guide a students to derive the combine gas equation
- Introduce the concept of an ideal gas and derive the ideal gas equation $pV = nRT$ explaining the symbols.
- Explain Dalton's law of partial pressure.
- Guide students to solve problems using ideal gas equation and gas laws.
- Direct students to perform practical works related to gas laws.

Laboratory experiments

- Determination of the atmospheric pressure using quill tube.
- Investigation of relationship between volume and temperature at constant pressure.
- Investigation of relationship between pressure and temperature at constant volume.

Competency Level 4.4 Inquires about the pressure exerted by a gas on its container using kinetic theory of gases.

No. of periods : 04

Learning outcomes :

- states the basic assumptions of the kinetic theory of gases.
- explains how molecular movement causes the pressure exerted by a gas
- relates temperature to the mean kinetic energy of molecules of a gas.
- explains the distribution of molecular speeds at different temperatures
- carries out calculations using the kinetic theory equation
- appreciates the kinetic theory of gases in explaining the behavior of gasses based on microscopic behavior of gas molecules.

Suggested learning-teaching activities

- Conduct a discussion regarding the pressure exerted by a gas on the wall of the container.
- State that gas laws describe the behavior of gases based on macroscopic view
- Explain that the kinetic theory of gases in used to describe the behavior of gases based on microscopic view
- Explain the distribution of molecular speed and root mean square speed.
- Explain the basic assumption of the kinetic theory of gases.
- Give the expression of kinetic theory of gases as $pV = \frac{1}{3}Nm\overline{C^2}$ hence deduce the pressure exerted by a gas as $p = \frac{1}{3}\rho\overline{C^2}$ and mean square speed as $\overline{C^2} = \frac{3RT}{M}$.
- Deduce the average translational kinetic energy of a gas molecule $E = \frac{3RT}{2N_A}$ and introduce $\frac{R}{N_A} = k$ Boltzmann constant.
- Guide the students to solve simple numerical problems using the kinetic theory equation.

Competency Level 4.5: **Quantities the amount of heat exchange among the objects using the specific heat capacity of substance.**

No. of periods: 08

Learning outcomes :

- defines heat capacity of an object.
- defines specific heat capacity of solids and liquids.
- defines molar heat capacities of gases.
- conducts experiment to find specific heat capacity of solids and liquids by the method of mixtures.
- carries out calculations considering heat exchange.
- expresses Newton's law of cooling.
- conducts experiment to find specific heat capacities of a liquid by the method of cooling.
- uses Newton's law of cooling to carry out calculations on heat loss.

Suggested learning-teaching activities

- Conduct a discussion recalling previous knowledge of heat capacity and show that the amount of heat exchange is proportional to temperature change and define heat capacity of a body and specific heat capacity of a substance.
- By discussion show that the change in the amount of heat of a body of mass m, heated to a temperature difference θ is given by $Q = mc\theta$
- Explain that gases have two molar heat capacities and define molar heat capacities.
- Introduce $\gamma = \frac{C_P}{C_V}$ where γ depends on the atomicity of the gas.
- Discuss the methods by which heat is lost to the surrounding during heat exchange and explain methods to reduce heat lost.
- Explain compensation method as a correction to the heat lost by changing the initial temperature.
- Direct students to carry out calculations using $Q = mc\theta$.
- Guide students to perform experiments to determine specific heat capacities of substances.
- Express the Newton's cooling law
- State the conditions for the validity of the law
- Obtain the expression $\frac{dQ}{dt} = kA(\theta - \theta_R)$ for the rate of heat loss introducing the terms.
- Deduce $\frac{dQ}{dt} = K(\theta - \theta_R)$ for the rate of cooling
- Assign students to solve problems using above expressions.

Laboratory experiments

- Determination of specific heat capacities of solids by the method of mixtures.
- Determination of specific heat capacities of a liquid by the method of cooling.

Competency Level 4.6 **Inquires about the productive use of the heat exchange during the change in phase of matter.**

No. of periods: 08

Learning outcomes

- describes qualitatively physical process associated with the change of state.
- states that melting and boiling take place without a change in temperature.
- defines specific latent heat of vaporization.
- defines specific latent heat of fusion.
- explains that specific latent heat of vaporization is higher than specific latent heat of fusion for the same substance.
- carries out numerical calculations of the latent heat of substance.
- identifies fusion and vaporization using the graph of temperature vs. time.
- conducts experiments to determine latent heat of fusion of ice .
- conducts experiment to determine latent heat of vaporization of water.
- states the effect of pressure on boiling point and melting point.

Suggested learning-teaching activities

- Explain the structure of matter by describing inter-molecular/particle attractive forces.
- Use suitable experiments and draw phase changing curves for fusion and vaporization to show that the temperature remains constant during changes of state.
- Explain that the term "latent heat" which means "hidden heat" is used because their heat is absorbed or emitted without any change of temperature taking place.
- Define the terms
    - Specific latent heat of fusion
    - Specific latent heat of vaporization
- Discuss some examples and carry out activities to show the effect of pressure on boiling point and melting point and hence decide that both boiling point and melting point change with pressure.

Laboratory experiments

- Determination of specific latent heat of fusion of ice.
- Determination of specific latent heat of vaporization of water.

Competency Level 4.7: **Relates the effect of water vapour on weather.**

No. of Periods: 08

Learning outcomes :

- differentiates evaporation and boiling
- explains the behavior of unsaturated and saturated water vapour.
- illustrates graphically the variation of saturated vapour pressure and unsaturated vapour pressure with temperature.
- explains the humidity refers to the moisture (amount of water vapour present) in the atmosphere.
- defines the dew point.
- defines absolute humidity.
- defines relative humidity.
- empresses relative humidity in terms of unsaturated vapors pressure and saturated vapor pressure at room temperature.
- expresses relative humidity in term of dew point and saturated vapor pressure at room temperature.
- carries out numerical calculations to solve problems on relative humidity, absolute humidity and dew point.
- correlates the boiling point and saturated vapour pressure
- conducts experiment of find Relative Humidity

Suggested learning-teaching process

- Explain and compare evaporation and vaporization (boiling).
- Explain the state of dynamic equilibrium between liquid and vapour.
- Describe the behavior of unsaturated vapour and saturated vapour.
- Describe using graphs, how unsaturated vapour pressure and saturated vapour pressure varies with volume, and with temperature.
- Describe the relationship between boiling point and saturated vapour pressure and explain how pressure affects the boiling point.
- Explain humidity as the measure of moisture content of the atmosphere and define absolute humidity and relative humidity.
- Explain dew point.
- Give expression for relative humidity using partial pressure and saturated pressure of vapour.
- Give expression for relative humidity using saturated vapour pressure at the temperature concerned and at the dew point.

- Guide students to carry out calculations related to absolute humidity, relative humidity and dew point.
- Guide students to conduct experiments to determine relative humidity.

Laboratory experiments

- Determination of relative humidity using polished calorimeter.

Competency Level 4.8: **Uses laws of thermodynamics to analyze the various thermodynamic processes.**

No. of Periods: 04

Learning outcomes :

- explains heat as a state of transfer of energy.
- relates a rise in temperature of a body to an increase in its internal energy.
- explains the first law of thermodynamics.
- uses the first law of thermodynamics to explain the changes of a gas.
- explains how the internal energy of a system changes during a constant pressure processes.
- explains internal or external work is done during a constant pressure processes.
- apply first law of thermodynamic for constant pressure processes.
- explains that the internal energy of a system changes during a constant volume processes.
- explains work done is zero during a constant volume processes.
- applies first law of thermodynamic for constant volume processes.
- explains that change of internal energy is zero during an isothermal processes.
- applies first law of thermodynamic for isothermal processes.
- explains that heat exchange is zero during the adiabatic processes.
- apply first law of thermodynamic for adiabatic processes.
- conducts simple activities to demonstrate, constant pressure constant volume, isothermal and adiabatic processes
- draws *p-V* curves for above processes.
- draws *p-V* curves for a given cyclic processes.
- explains given cyclic processes using *p-V* curves
- carries out numerical calculations using the first law of thermodynamics.

Suggested learning-teaching process

- Point out the importance of temperature in the transfer of heat.
- Introduce heat as energy in transit.
- Describe how internal energy changes due to absorption or emission of heat and how it relates to the temperature of a gaseous system.
- State and explain the first law of thermodynamics.
- Discuss + and – signs of the quantities ΔQ, ΔU and ΔW
- Describe constant pressure process and show that work done in it is $p.\Delta V$
- Describe constant volume process and show that work done in it is zero.

- Explain isothermal process and show that $\Delta U=0$ for a gaseous system undergoing this process.
- Explain adiabatic process and point out $\Delta Q=0$ for it.
- Discuss the temperature changes taken place in adiabatic compression and expansion of a gas.
- Introduce p-V curve and discuss the shapes it can be take.
- Show that ΔW is given by the area under the p-V curve.
- Describe the cyclic process.
- Explain how ΔW can be found for a cyclic process.
- Assign and discuss questions based on the first law of thermodynamics.
- conducts simple activities to demonstrate, constant pressure constant volume, isothermal and adiabatic processes
- draws p-V curves for above processes.
- draws p-V curves for a given cyclic processes.
- describe given cyclic processes using p-V curves
- carries out numerical calculations using the first law of thermodynamics.

Competency Level 4.9: **Designs daily and scientific work by considering the methods and amount of transfer of heat.**

No. of Periods: **06**

Learning outcomes :

- describes heat transfer mechanisms indicating conduction, convection and radiation.
- illustrates temperature distribution of lagged and non lagged uniform rods graphically.
- introduces temperature gradient.
- expresses equation for the rate of conduction of heat.
- carries out numerical calculations related to thermal conduction.
- defines heat conductivity
- explains convection and radiation qualitatively.
- conducts an experiment to determine thermal conductivity using Searle's method.

Suggested learning-teaching process

- Introduce the three ways of transferring of heat – conduction, convection and radiation.
- Explain conduction and its mechanism.
- Explain the steady state of flow of heat.
- Introduce the graphs of temperature distribution along a rod when it is conducting heat in the steady state. Consider where the rod is lagged and where the rod is not lagged.
- Use the above graphs to focus on the idea of temperature gradient.
- Point out how logging leads to the axial flow of heat along a rod.
- Discuss the factors on which the rate of conduction of heat along a rod depends. The cross sectional area and the temperature gradient.
- Introduce and discuss the equation $\frac{\Delta\theta}{\Delta t} = kA\frac{(\theta_1 - \theta_2)}{l}$.
- Define thermal conductivity and obtain its units and dimensions.
- Explain the mechanism of convection.
- Make a brief account of radiation of heat in the infra-red band of the electromagnetic spectrum.
- Discuss the difference of radiation when compared with conduction and convection.
- Assign questions based on conduction of heat to be answered.
- Guide students to perform the experiment
- Determination of thermal conductivity of a metal using Searle's method.