G. C. E. (Advanced Level)

# Physics

## Teacher's Instructional Manual

*(Implemented from 2012)*

## Grade 12

**Department of Science, Health & Physical Education**
**Faculty of Science & Technology**
**National Institute of Education**

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**Physics**
**Teacher's Instructional Manual**
**Grade 12**

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*Cover page –*
*Glashow's snake: the cosmic puzzle. The concept of a snake swallowing its own tail is of Indian origin. The Nobel Prize – winning physicist Sheldon Lee Glashow drew of the idea to depict our view of the universe, from the very large to the very small.*

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# Director General's Message

Curriculum developers of the NIE were able to introduce Competency Based Learning and Teaching curricula for grades 6 and 10 in 2007 and were also able to extend it to 7, 8 and 11 progressively every year and even to GCE (A/L) classes in 2009. In the same manner syllabi and Teacher's Instructional Manuals for grades 12 and 13 for different subjects with competencies and competency levels that should be developed in students are presented descriptively. Information given on each subject will immensely help the teachers to prepare for the Learning – Teaching situations.

I would like to mention that curriculum developers have followed a different approach when preparing Teacher's Instructional Manuals for Advanced Level subjects when compared to the approaches they followed in preparing Junior Secondary and Senior Secondary curricula. (Grades 10, 11)

In grades 6, 7, 8, 9, 10 and 11 teachers were oriented to a given format as to how they should handle the subject matter in the Learning – Teaching process, but in designing AL syllabi and Teacher's Instructional Manuals freedom is given to the teachers to work as they wish.

At this level we expect teachers to use a suitable learning method from the suggested learning methods given in the Teacher's Instructional Manuals to develop competencies and competency levels relevant to each lesson or lesson unit.

Whatever the learning approach the teacher uses it should be done effectively and satisfactorily to realize the expected competencies and competency levels.

I would like to note that the decision to give this freedom is taken, considering the importance of GCE (A/L) examinations and the sensitivity of other stakeholders who are in the education system to the Advanced Level examination. I hope that this Teacher's Instructional Manual would be of great help to teachers.

I hope the information, methods and instructions given in this Teacher's Instructional Manual will provide proper guidance to teachers to awaken the minds of our students.

**Professor Lal Perera**
Director General
National Institute of Education

# Foreword

Action taken over long years of the past to retain the known and learn the predetermined has made us little able today to construct even what is. The first curriculum reform of the new millennium on secondary education that comes to being with a drastic change in the learning-teaching process at school level attempts to overcome this inability while bringing about a set of worthy citizens for the country who are capable of revising the known, exploring the undetermined and constructing what might be.

If you are a teacher teaching this subject or any other subject in grades 6 to 11, it will not be difficult for you to align yourself with the new learning-teaching approaches that are recommended in a considerable way for the GCE (A/L) as well. This reform calls the teacher to identify competency levels under each competency and plan activities to achieve them. The teachers entering the new role of transformation should understand that the procedures which emphasize the teacher in the learning-teaching process are of limited use for the present and that it is more meaningful for the children to learn co-operatively sharing their experiences. This situation, however, requires the teachers to provide a new direction for their teaching by selecting new learning–teaching methods that emphasize the student over the teacher.

If you study the Teachers' Instructional Guides (TIGs) prepared by the National Institute of Education for Mathematics, Science, Health & Physical Education, Technology and Commerce subject of grades 6 to 11, you certainly will be able to acquire a good understanding on the student-centred, competency based and activity- oriented approaches we have recommended for learning and teaching. The activities presented in these Guides attempt to bring learning, teaching assessment and evaluation on to the same platform and to help you to adopt co-operative learning techniques on the basis of the 5E Model.

Considering the need to establish an innovative teaching force we have selected just a few activities from the relevant activity continuum incorporated in the TIGs. Yet we have given you a vast freedom to plan your own activities to suit the subject and the class requirements by studying the exemplar activities in the Guides and improving your understanding on the principles underlying the reform. The activities incorporated in the TIG, provide you with four types of information. At the beginning of each activity you come across the final outcome that the children are expected to achieve through each activity. This learning outcome named as 'Competency' is broad and long-term. The competency level stated next highlight one out of the number of abilities that the children have to develop to realize the competency.

The above explanation shows us that the competency levels are more specific and of a shorter duration when compared to the competency. The next section of the Guide presents a list of behaviours that the teacher has to observe at the end of each activity. To facilitate the task of both the teacher and the students, an attempt has been made to limit the number of such behaviours to five. These behaviours referred to as learning outcomes are more specific than the competency level. They include three abilities derived from the subject and two others derived from the learning teaching process. Out of the three subject abilities listed in an order of difficulty, the teacher has to direct the children to realize at least the first two through the exploration. The next section of the activity presents what the teacher should do to engage the children for the exploration. Although the implementation of each and every activity starts with this step of engagement, the teachers should not forget that activity planning should begin with the exploration which is the second 'E' of the 5E Model.

Instructions for the group exploration from the next section of the exemplar activities the teacher plans these instructions in such a way to allow different groups studying different facets of the same problem to reach the expected ends through a variety of learning-teaching methods. For this, further the teacher can select either Inquiry-based Learning carried out through a series of questions or Experiential Learning where children learn by doing. It is the responsibility of the GCE (A/L) teacher to use the knowledge that the children acquire by any of the above methods to solve problems that are specific to the subject or that runs across a number of subjects of the curriculum is meaningful to plan such problem-based learning-teaching methods on the basis of real-life situations. For this you can select dilemmas, hypothetical situations, analogies or primary sources. Some techniques that can be used for the explorations are reading, information management, reflection, observation, discussion, formulation and testing of hypotheses, testing predictions, preparing questions and answers, simulation, problem solving and aesthetic activities such as drawing or composing. There is room here even for memorization although it is considered as a form of mechanical learning.

The students explore in small groups. Instead of depending on the knowledge available to the teacher, they attempt to construct their own knowledge and meaning with the support of the teacher. Moreover, they interact with others in the group to learn from others and also to improve the quality of their exploration findings. All this works successfully only if the teacher is capable of providing the students with the reading material and the other inputs they are in need of. The teacher also has to support student learning throughout the learning process by moving from one group to another. Although it is the discovery that is prominent in this type of learning you have to recognize this as a guided discovery rather than a free discovery. There is no doubt that students learning likewise with instructional scaffolding both by the teacher and the peers acquire a whole lot of worthwhile experiences that they find useful later in life.

Explanation follows the second stage of exploration. The small groups get ready to make innovative, team presentations on their findings. The special feature here is that the children have selected novel methods for their presentations. The responsibility for the presentation is also shared by all members of the group. In the next step of elaboration the children get the opportunity to clarify the unclear, correct the incorrect and fill any gaps that are left. They also can go beyond the known to present new ideas. All activities end with a brief lecture made by the teacher. This stage allows the teacher to go back to the transmission role. The teacher also has to deliver this lecture covering all the important points that the syllabus has prescribed for the relevant competency level. Step 3 of each Activity Plan guides the teachers in this compulsory final elaboration.

To overcome many problems that are associated with the general system of education today, the National Institute of Education has taken steps to move the teachers to the new transformation role recommended for them. This role that starts with a transaction gets extended to a lengthy exploration, a series of student explorations and elaborations and a summative transmission by the teacher. The students involve themselves in the exploration using reading material and other quality inputs provided to them by the teacher.

The students attend school daily to learn joyfully. They achieve a number of competencies that they need to be successful in life and the world of work. They prepare themselves for nation building by developing thinking skills, social skills and personal skills. For the success of all this, an examination system that inquires into the ability of students to face real challenges of life is very much needed in place of an examination system that focuses on the knowledge acquired by children through memorizing answers to model questions.

A number of activities have already begun at the national level to protect the real nature of school-based assessments. The written tests have been minimised to gain recognition for school-based assessments. Compulsory question has been incorporated in the term tests along with a scheme of authentic evaluation to ensure real outcomes of learning. It is the co-ordinated responsibility of all citizens of the country to open up doors for a new Sri Lanka by thriving for the success of this new programme on the basis of sound instructional leadership and quality assurance by the management.

**Deshamanya Dr (Mrs) I L Ginige**
Assistant Director General (Curriculum Development)
Faculty of Science and Technology

## Message of the Commissioner General

While the Government provides textbooks free to all the students, Teacher's Instructional Manuals are also provided free to all the teachers. The aim is to make the process of teaching-learning more fruitful and effective.

The Teacher is the mediator who monitors and directs the students to achieve the competencies contained in the syllabus. Hence, it is your responsibility to understand your duties well and use this Teacher's Instructional Manual to achieve a substantial knowledge of the teaching process. This will enable you to make the students knowledgeable and motivated to derive the maximum benefits from the competency based learning process.

I hope that this Teacher's Instructional Manual will assist the teachers who shoulder the solemn duty of moulding the student population enabling them meet the challenges of contemporary society.

**W. M. N. J. Pushpakumara**
Commissioner General of Educational Publications

Educational Publications Department,
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# Table of Contents

# Unit 1: Measurement

**Competency 1** : **Uses experimental and mathematical frames in physics for systematic explorations.**

**Competency level 1.1**: Inquires the scope of physics and how to use the scientific methodology for explorations.

**No of periods** : 04

**Learning outcomes**:

Student will be able to:

- explain physics as the study of energy, behaviour of matter in relation to energy and transformation of energy.
- describe physics as a subject that focuses to very large scale, from fundamental particles, fundamental forces to huge structure of the Universe.
- express how to use principles of physics in day-to-day life activities and to explain natural phenomena.
- elaborate how physics has been applied in modern civilization such as
    - Transportation
    - Communication
    - Power supply
    - Medical applications
    - Earth and space explorations
- use scientific method for scientific explorations.
- accept that advancements in physics are based on observation and inferences made on them.

**Guidelines:**

- Physics as the study of energy and behaviour of matter
- Subject area of physics
- Physics in day-to-day life
- The steps of scientific method
    - Observation
    - Hypothesis
    - Experiment
    - Theory or law
    - Prediction

**Observation**
The first step in scientific method is to make careful observations to collect data. The data may be drawn from a simple observation, or they may be obtained from experiments.

**Hypothesis**
From an analysis of these observations and experimental data, a model of nature is hypothesized. The hypothesis is an assumption that is made in order to draw out and test its logical or empirical consequences. We should be able to confirm it by testing. Testing of the hypothesis is called the experiment.

**Experiment**
An experiment is a controlled procedure carried out to discover, test, or demonstrate something. An experiment is performed to confirm that the hypothesis is valid. If the results of the experiment do not support the hypothesis, the experimental procedure must be checked. If the procedure is alternate and results still contradict the hypothesis, then the original hypothesis must be modified. Another experiment is then design to test the modified hypothesis.

**Theory**
If the experimental results confirm the hypothesis, the hypothesis becomes a new theory about some specific aspect of nature, a scientifically acceptable general principle based on observed facts.

**Prediction**
After a careful analysis of the new theory, a prediction about some unknown aspect of nature can be made.

**Suggested learning/teaching activities:**

- Conduct a discussion comparing various science subjects learnt in the O/L class to distinguish the subject area (scope of physics).

- Assign students to explore
  - how physics is used to explain natural phenomena such as rain, day and night, earthquakes, etc.
  - applications of physics in transportation, communication, power supply, medical applications, earth and space explorations.
  - how physics is used to make the life of modern civilization more comfortable.

- Introduce scientific method as a systematic way for scientific explorations.

- Discuss limitations of the scientific method.

**Competency level 1.2:** Uses units appropriately in scientific work and daily pursuits.

**No of periods**: 02

**Learning outcomes:**

Student will be able to:

- describe basic physical quantities and derived physical quantities.
- use appropriate basic SI units and derived SI units to measure physical quantities.

**Guidelines:**

- Seven basic physical quantities.
- Seven basic SI units and two supplementary SI units used in the measurement of physical quantities *(Table 1.1)*.

| **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 | sr |

*Table 1.1 Seven basic SI Units and two supplementary units*

- Derived quantities in terms of basic quantities.
- Units of some derived quantities in terms of basic units.
- Special names of some derived units (*Table 1.2*).
- Prefixes to indicate multiples or sub multiples of SI units.
- Value, name and symbols of some prefixes.
- Some physical quantities that do not have 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 | Ω =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*

**Suggested learning/teaching activities:**

- Mention British system of units and cgs system of units as examples.
- Discuss few difficulties that may arise, during transfer of knowledge and trade activities.
- Introduce mass, length, time, electric current, luminous intensity, thermodynamic temperature and amount of substance as the seven basic quantities.
- Introduce the units and the symbols of basic units.
- Explain that quantities such as area, volume, density, speed, acceleration, force etc can be expressed in terms of basic quantities and name them as derived physical quantities.
- Select some physical quantities learnt in the O/L class and tabulate them with their SI units.
- Introduce the special names and their symbols of the derived units *(Table 1.2).*
- Explain the use of multiples and submultiples of SI units. Introduce the prefixes.
- Explain that the prefix is written in front of the SI unit with no space between the two symbols. The method of expressing the multiplication of units is to write the symbols with one space between them.
- Give few examples;
  mm, ms, N m
- Select few examples and familiarize with expressing and writing the value of the units.

**Competency level 1.3**: **Investigates physical quantities using dimensions**.

**No of periods:** 02

**Learning outcomes:**

Student will be able to

- use dimension to check and derive equations and determine units of physical quantities.

**Guidelines:**

- Dimensions of mass, length, and time are denoted by M, L and T respectively.
- Dimensions of derived physical quantities in terms of basic dimensions.
- Checking the correctness of an equation using dimensions.
- Relationship of physical quantities with respect to a given occurrence.
- Dimensions or units of an unknown quantity in an equation.
- Quantities without units have no dimensions.
  eg. refractive index
  coefficient of friction

**Suggested learning / teaching activities:**

- Explain that dimensions show how a derived quantity is related to the basic quantities.
- Explain that the dimensions of a quantity are independent of the system of units using examples such as velocity, acceleration and force.
- Discuss some examples on how to check the validity of an equation.
- Derive relationship between physical quantities.
  e.g.
  Assuming that the period of oscillation of a simple pendulum depends on its length and acceleration due to gravity at that place, derive a relationship among the physical quantities.

**Competency level 1.4**: **Takes measurements accurately by selecting appropriate instruments to minimize the error.**

**No of periods:** 08

**Learning Outcomes:**

Student will be able to:

- describe the importance of taking measurements during experiments and in day-to-day life.
- use suitable measuring instruments to measure various physical quantities.
- use Vernier calliper, travelling microscope, micrometer screw gauge, spherometer, triple beam balance, four-beam balance, electronic balance, stopwatch and digital watch to take readings.
- count the error of a measuring instrument.
- calculate fractional error and percentage error.
- estimate the influence of relative magnitudes of errors in the final result of an experiment.

**Guidelines:**

- Measurement has a magnitude and a unit.
- Measurements of physical quantities can vary over a wide range.
  - Measurements in length from very small values to very high values (sub atomic particles to furthest distance observed in universe, $10^{-15}$ m to $10^{27}$ m).
  - Measurements in time from very small values to very high values (atomic behaviour to age of the universe, $10^{-24}$ s to $10^{18}$ s).
  - Measurements in mass from very small mass of an electron $10^{-31}$ kg to $10^{40}$ kg.
- Least count and zero error of the instrument
- Absolute error
- Fractional error
- Percentage error
- Vernier principle
- Screw gauge principle

**Working with errors (Working with uncertainties)**

Systematic errors (systematic uncertainties)
These occur due to faulty apparatus such as an incorrectly labelled scale, an incorrect zero mark on a meter or a stopwatch running slowly. Repeating the measurement a number of times will have no effect on this type of error and it may not even be suspected until the final result is calculated. To eliminate this type of error, a correction can be introduced to the final reading the instrument can be recalibrated or replaced.

Random errors (random uncertainties)
The size of these errors depends on how well the experimenter can use the apparatus. The better the experimenter, the smaller will be the random error that will reflect in an experiment. Making a number of readings of a given quantity and taking an average will reduce the overall error.

In a measuring instrument there is a scale. There is a least count that can be obtained from the scale. We can't take measurements with accuracy higher than the least count by using the instrument. For example, the least count of the metre ruler is 1 mm. Therefore, we can't expect a measurement with a higher accuracy than 1mm from a metre ruler. That is, though we can express readings like 17.3 cm or 17.4 cm using a metre ruler, we can't express a reading like 17.35 cm. using a metre ruler.

The maximum error can be occurred during a measurement is the least count of the scale.

The size of the error needs to be considered together with the size of the quantity being measured.
For example,

$(208 \pm 1)$ mm is a fairly accurate measurement.
$(2 \pm 1)$ mm is highly inaccurate

In order to compare error, use is made of absolute, fractional and percentage error.
For the reading $(208 \pm 1)$ mm;

1 mm is the absolute error
1/208 is the fractional error (=0.0048)
0.48% is the percentage error

As we usually require error to only one significant figure, the two values given above would be used as 0.005 and 0.5%, respectively.

The accuracy of a measurement is considered to be sufficient if the percentage error is 1 % or less than 1%. When we use a metre ruler for measuring a length of 100mm, the percentage error is $\frac{1}{100} \times 100 = 1\%$. Therefore, it is considered that the accuracy obtained from a metre ruler is not sufficient in measuring lengths shorter than 10cm. In such a situation, an instrument with a least count lower than 1 mm is used. Instruments made based on the Vernier principle or screw gauge principle can be used for this.

When we calculate a final result like $y = a^n b$, the error of the quantity "$a$" will have a greater effect in the error in $y$. Therefore, we have to take an extra care in measuring terms raised to powers.

**Suggested learning / teaching activities:**

- Explain that measurements of physical quantities can vary over a wide range using examples.
- Explain the Vernier principle and screw gauge principle.
- Explain least count and zero error.
- Demonstrate how to use electronic balance, digital watch, triple beam balance and four-beam balance.
- Let the students do the following activities.
    - Measure the length, breadth and thickness of a thin piece of wood.
    - Calculate the fractional error and percentage error of each measurement.
    - Take the same measurement using different measuring instruments and then compare the percentage errors.
- Stress the importance of least count.

**Laboratory practical**:

- Uses of measuring instruments
- Vernier calliper
- Micrometer screw gauge
- Spherometer
- Travelling microscope

**Competency level 1.5**: **Uses vector addition and resolution appropriately.**

**No of periods:** 04

**Learning Outcomes:**

Student will be able to:

- use vector resolution method to find the resultant of a system of forces.
- use vector method to find total displacement, resultant of velocities and resultant of forces.

**Guidelines:**

- Concept of vectors and scalars.
- Difference between vectors and scalars.
- Scalars may be added together by simple arithmetic but when vectors are added the direction of the vector must also be considered.
- A vector may be represented by a line; the length of the line being the magnitude of the vector and the direction of the line the direction of the vector.
- Vector addition
  - Vector parallelogram rule
  - Vector triangle method
- Vector resolution

**Suggested learning/teaching activities:**

- Introduce the geometrical representation of a vector.
- Construct the vector triangle method for vector addition considering the displacement vector.
- Introduce the parallelogram rule of vector.
- Introduce vector resolution.
- Discuss several examples using vector parallelogram rule, vector resolution method and vector triangle method to find the resultant of vectors.

**Competency level 1.6:** **Extracts information correctly by graphical representation of experimental data.**

**No of periods:** 02

**Learning outcomes:**

Student will be able to:

- interpret and predict the behavior of variables using graphs.

**Guidelines:**

**Graphical representation of experimental data**

It is often difficult to grasp the relationship exiting between the numbers by examining the tabulated values of a number of measurements of related quantities. A method widely used to discover such relationship is the graphical method, which gives a pictorial view of the results and makes it possible to interpret the data at a glance.

Independent and dependent variables

In many experiments we always vary just one variable at a time and observe the corresponding values of another quantity, which is suspected of being related to the first. The relationship, if any, is most easily interpreted from the graph if the first of these quantities, the independent variable, is plotted on the abscissa scale (X-axis) and the dependent variable is plotted on the ordinate scale (Y-axis).

Choice of scale

Choose the range of scale so that the graph will fit the entire graph sheet. Note the range of values of the independent variable (X quantity), and the number of spaces along the X-axis. Choose a scale for the main divisions on the graph paper that are easily subdivided such that all the values may be included. Subdivisions such as 1, 2, 5 and 10 are the best, 4 is sometimes used; but never use 3, 7, or 9 since these make it very difficult to read values from the graph. The same procedure should be used for the ordinate scale, but the divisions on the ordinate and abscissa scales need not be alike. In many cases it is not necessary that the intersection of the two axes represent the zero values of both variables. if the values to be plotted are exceptionally large or small, use some multiplying factor that permits using a maximum of two or three digits to indicate the value of the main division. A multiplying factor such as $x10^2$ or $x10^{-6}$ placed at the right of the largest value on the scale may be used.

Labeling

After deciding which variable is to be plotted on which axis, write down the quantity being plotted together with the proper unit. Then write the numbers along main divisions on the graph paper, using an appropriate scale as explained in the proceeding paragraph. The title should be neatly written on the top of the graph paper.

Plotting and drawing the graph

Using a sharp pencil, make small dots to locate the points and carefully encircle each point with a small circle. In drawing the graph it is not always possible to make all points lie on a smooth curve. In such cases, a smooth curve should be drawn through the series of points to follow the general trend and thus represent an average. Most of the graphs of A/L experiments are straight lines. At least six data points should be used to draw a reasonable straight line. The best straight line can easily be seen by holding a string or a transparent ruler so that the data points are equally distributed either side of the line.

The shape of a graph

This immediately tells us whether the dependent variable increases or decreases with the increase of the independent variable. It also shows something about the rate of change. If the points lie along a straight line, there is a linear relationship between the variables. If the variables are directly proportional to each other, they approach zero simultaneously, and the line passes through the origin. Curves which are straight lines and do not pass through the origin do not indicate direct proportion.

The slope or the gradient

The slope of the variable is found by dividing $\Delta Y$ by $\Delta X$ . The two points P($x_1$,$y_1$) and Q($x_2$,$y_2$) should lie far apart as possible. Avoid taking data points for P or Q.

Intercepts

Significant information is often revealed by the intersections of the graphs with the coordinate axes. This is true for other types of curves as well as for straight lines. A direct interpretation of the intercept can be obtained only if the scale used begins at zero. If this is not the case intercept can be calculated using the gradient and one set of coordinates on the straight line. If the plotted points indicate a trend, one may be justified in extrapolating the graph. Extrapolation is accomplished by extending the graph in the desired direction by a dotted line, rather than by a solid line, thus indicating that experimental data are not available for this portion of the curve.

Units

Care should be taken to use correct units in calculations. These calculations will give meaningful results only when all physical constants and measured quantities are in a consistent set of units.

**Suggested learning/teaching activities:**

- Describe the important point to bear in mind when plotting a graph.
    - selecting the independent variable
    - selecting the dependent variable
    - title of the graph
    - the scale makes good use of the space available on the graph paper
    - axes are labeled with quantity an units

- Assign students to illustrate data graphically and to predict the behaviour of variables.

# Unit 2: Mechanics

**Competency 2.0**: **Lays a foundation for analyzing motion around us on the basis of principles of physics.**

**Competency level 2.**1: **Analyzes the linear motion, projectile motion and relative motion of bodies.**

**No of periods:** 10

**Learning outcomes:**

Student will be able to:

- calculate the position and velocity of an object relative to another object moving at constant relative velocity on parallel paths in the same direction and in opposite directions.
- use equations of motion for constant acceleration to describe and predict the motion of an object moving in a straight line .
- describe the variables related to projectile and through calculations, predict where a projectile will land.
- use graphs of displacement vs. time and velocity vs. time to calculate acceleration, velocity and displacement as appropriate.

**Guidelines:**

- Concept of relative motion.
- Expressions for the relative velocity of two bodies traveling in parallel directions relative to earth.

$$V_{(A,B)} = V_{(A,E)} + V_{(E,B)}$$

- Relative motion on parallel paths
  - in the same direction
  - in opposite direction
- Illustrating the linear motion using
  - displacement vs time (*s-t*) graph
  - velocity vs time( *v-t*) graph
- Transformation of a simple *s-t* graph to *v-t* graph and vice-versa.
- Problems solving and predicting the following types of motions.
  - Motion on a horizontal plane under constant acceleration
  - Vertical motion under gravity
  - Motion on a frictionless inclined plane
  - Projectiles

**Suggested learning/ teaching activities:**

- Use the concept of relative motion to explain related phenomena.

- Discuss several examples to explain the relative motion such as the apparent direction of motion of a rain drop as seen by a person traveling in a train, motion of geostationary satellites, etc.

- Introduce $V_{(A,B)} = V_{(A,E)} + V_{(E,B)}$ for three frames of reference A, B and E (Derivation not needed).

- Provide relevant problems to solve using above equation.

- Plot and interpret
  - distance- time graph
  - displacement-time graph
  - velocity- time graph and describe what information can be obtained from the graphs

- Obtain equations of motion using *v-t* graphs.

- Provide relevant problems to solve using equations of motion.

**Competency level 2.2:** **Uses resultant force and moment of force to control linear motion and rotational motion of a body.**

**No of periods**: 12

**Learning outcomes:**

Student will be able to

- use the rules for resolving and adding forces.
- calculate the turning effect of a force.
- find the centre of gravity of regular shaped compound bodies.

**Guidelines:**

- Characteristic properties of a force.
- Resultant of two concurrent forces using force parallelogram rule.
- Resultant of like and unlike two parallel forces
- Resultant of a system of forces using
  - Force polygon method.
  - Force resolution method.
- Definition of moment and calculation of the turning effect of a force.
- Moment of a couple.
- Net moment of a system of coplanar forces.
- The concept of centre of gravity of a body using the resultant of parallel forces.
- The concept centre of mass.

**Suggested learning/ teaching activities:**

- Demonstrate using examples that force has a magnitude, a direction and a point of application (give some examples).
- Derive an equation using the parallelogram law to find the magnitude and direction of the resultant of two inclined forces.
- Discuss situations when $\theta = 0^0$, $90^0$ and $180^0$ and when two forces are same in magnitude.

- Use force polygon method and force resolution method to find the resultant of coplanar forces.
- Discuss turning effect of a rigid body using the terms ‘moment of a force’ and ‘moment of couple’.
- Introduce the centre of gravity of an object.
- Determine the centre of gravity of a laminar.
- Assign students to find the centre of gravity of regular shaped compound bodies using the resultant of parallel forces.

**Laboratory practical:**

- Determination of weight of a body using the Parallelogram law of forces.

**Competency level 2.3**: **Manipulate the conditions necessary to keep a body in equilibrium.**

**No of periods**: 10

**Learning Outcomes:**

Student will be able to:

- analyze the conditions for equilibrium of a point object.
- describe the conditions for equilibrium of three coplanar forces in parallel and at an angle to each other.
- use the triangle of forces theorem and the principle of moments to solve simple problems related to equilibrium of forces.

**Guidelines:**

- Equilibrium of a point object
- A point object is said to be in equilibrium if the resultant force acting on it is zero.
- Equilibrium of a rigid object
- If a rigid object is in equilibrium,
  I. the resultant force is zero in all directions and
  II. the total torque is zero about any axis.

  The statement II is called the principle of moments.
- Equilibrium under three concurrent coplanar forces.
- Equilibrium under three parallel forces.
- Triangle of forces theorem.
- Polygon of forces.
- States of equilibrium
  - Stable
  - Unstable
  - Neutral

**Suggested learning/teaching activities:**

- Demonstrate the general conditions for a system of coplanar forces to be in equilibrium.
- Discuss equilibrium under three concurrent coplanar forces.
- Discuss equilibrium under three parallel coplanar forces.
- Explain the triangle of forces theorem.
- Explain the principle of moments.

**Laboratory practical:**

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

**Competency level 2.4: Uses Newton's laws of motion to control the states of motion of a body.**

**No of periods:** 16

**Learning Outcomes:**

Student will be able to

- use Newton's laws of motion and the concept of momentum to analyze dynamic situations involving constant mass and constant forces.
- carry out calculations on force and motion.
- analyze the effects of friction on dynamic systems.
- Use free body diagrams to analyze the forces acting on a body and determine the net force.

**Guidelines:**

- The concept of inertia.
- Gravitational mass and inertial mass.
- Inertial and non-inertial frames.
- Introducing the concept of inertial forces to explain forces in non-inertial frames.
- Linear momentum and impulse.
- Newton's laws of motion
  - Newton's first law
  - Definition of force
  - State of dynamic equilibrium of a body which is not under acceleration
  - Motion without friction (hypothetical situations)
  - Newton's second law
  - Deriving $F = ma$
  - Definition of 'newton'
  - Newton's third law
  - Action and reaction
  - All forces exist (occur) in pairs
  - Forces are mutually acting on bodies
- Principle of conservation of linear momentum.
- Application of the conservation of momentum to collisions in a straight line and to explosions.

- Self adjusting forces
  - Tension
  - Thrust
  - Friction
    - Static friction
    - Dynamic friction
    - Coefficient of friction

- Free-body diagrams.

- Application of Newton's laws in a wide variety of situations (where the mass of an object acted on by one or more forces is constant).

- The general link between force and motion is not that force is needed to maintain motion. It is that force is required to change motion. In other words, to change the velocity of an object, the object must be acted on by a resultant force. If there is no resultant force acting on an object, its velocity remains the same. If there is a resultant force acting on an object, its velocity must change.

**In solving problems related to Newton's laws, the following procedure is recommended.**

1. State clearly which object is being considered.
2. Draw a free body sketch of that object only.
3. Mark on the sketch the gravitational pull on the object, its weight.
4. Mark on the sketch, all the points where the object touches any thing else and draw in the contact forces at these points. Label all forces clearly.
5. Decide which direction to call positive for the total force and acceleration.
6. Apply Newton's second law equation.

If you follow this procedure, you will be able to solve all the related problems. You will not need to use a different approach in complicated situations arise.

**Suggested learning/ teaching activities:**

- Give examples to explain the concept of inertia (fly wheel).

- Compare the concept of inertial mass and the gravitational mass.

- Explain that the resistance to change of state of motion is known as inertia.

- Use normal gravitational balance to find gravitational mass.

- Explain the difference between inertial frames and non-inertial frames.

- Introduce inertial forces in non-inertial frames using examples such as centrifugal force, Coriolis force etc.

- Explain the concept of force using Galileo's inclined plain experiment.

- Explain that a body which is not under acceleration is in a state of dynamic equilibrium.

- Demonstrate the motion when there is no friction.

- Demonstrate using the ticker or other suitable activity,

  $a \propto F$ (when $m$ is constant) and

  $a \propto \frac{1}{m}$ (when $F$ is constant)

- Use linear air track to demonstrate.
  - Newton's laws of motion and
  - the principle of conservation of linear momentum

- State that Newton's second law of motion in terms of both momentum and velocity changes.

- Use the laws of friction to explain dynamic and static situations.

- Explain the situations using free body diagrams.

**Competency level 2.5: Investigate the concept related to rotational motion and circular motion.**

**No of periods:** 16

**Learning Outcomes:**

Student will be able to:

- predict the motion of a rotating body by determining the forces acting on it.
- analyze situations in which an object moves round a circle at constant speed.
- calculate the centripetal acceleration of an object moving round a circular path at a constant speed.
- relate the centripetal acceleration of such an object to the forces acting on it.
- Carry out calculations related to rotational motion and circular motion

**Guidelines:**

- Terms related to rotational motion.
  - Angular displacement
  - Angular velocity
  - Angular acceleration
  - Frequency of rotation

  and relate them with quantities in linear motion.

  $s = r\theta, v = r\omega, a = r\alpha$

  $\omega = 2\pi f, \omega = \frac{2\pi}{T}$

- Equations of rotational motion.
- Moment of inertia as the inertia of rotational motion.
- Moment of inertia varies with mass and with distance from the axis of rotation.
- Moment of inertia of a mass distribution $I = \sum m_i r_i^2$
- Angular momentum $L = I\omega$
- Conservation of angular momentum $I_1\omega_1 = I_2\omega_2$
- Torque $\tau = I\alpha$

- For an object in uniform circular motion in a horizontal plane
    - its instantaneous velocity is tangential
    - its acceleration is towards the centre.

- Terms related to uniform circular motion.
    - Frequency
    - Tangential speed
    - Period
    - Centripetal force
    - Centripetal acceleration $\frac{v^2}{r}$ and $r\omega^2$

**Suggested learning/ teaching activities:**

- Discuss day to-day experiences that can be explained using principles of rotational motion.

- Use rotating table to demonstrate the relationship between angular velocity and the moment of inertia.

- Observe the rotation where person seated on a rotating chair holding a rotating wheel horizontally, gradually makes its axis vertical and horizontal.

- Use the apparatus available in the laboratory to demonstrate rotational motion.

- Observe the change in angular velocity of a person seated on a rotating chair holding two loads in each hand as the extends his arms and brings them closer.

- Explain that if there is no net external torque acts on a system, the total angular momentum of the system remains constant.

- Develop the law of conservation of momentum.

- Show that the acceleration of a body travelling in a circular path directed towards the centre is given by $\frac{v^2}{r}$ and $r\omega^2$.

- Compare linear motion and rotational motion (*Table 2.1*).

**Correspondance between linear and angular motions**

| Linear motion | | Rotational motion | |
|---|---|---|---|
| Displacement | $s$ | Angular displacement (in radians) | $\theta$ |
| Velocity | $v = \frac{ds}{dt}$ | Angular velocity | $\omega = \frac{d\theta}{dt}$ |
| Acceleration | $a = \frac{dv}{dt}$ | Angular acceleration | $\alpha = \frac{d\omega}{dt}$ |
| For constant acceleration | $v = u + at$<br>$s = ut + \frac{1}{2}at^2$<br>$v^2 = u^2 + 2as$ | For constant angular acceleration | $\omega = \omega_0 + at$<br>$\theta = \omega_0 t + \frac{1}{2}at^2$<br>$\omega^2 = \omega_0^2 + 2\alpha\theta$ |
| Mass (measures linear inertia) | $m$ | Moment of inertia (measures rotational inertia) | $I = \sum m_i r_i^2$ |
| Force | $F$ | Couple or torque | $\Gamma$ |
| Momentum | $mv$ | Angular momentum | $I\omega$ |
| Work | $Fs$ | Work | $\Gamma\theta$ |
| Impulse | $Ft$ | Angular impulse | $\Gamma t$ |
| Kinetic energy | $\frac{1}{2}mv^2$ | Energy | $\frac{1}{2}I\omega^2$ |
| Equation of motion | $F = ma$<br>$F = \frac{d(mv)}{dt}$ | Equation of motion | $\Gamma = \frac{d(I\omega)}{dt}$ |

| For a constant force F: | | For a constant torque $\Gamma$ | |
|---|---|---|---|
| Work done | $Fs = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$ | Work done | $\Gamma\theta = \frac{1}{2}I\omega_2^2 - \frac{1}{2}I\omega_1^2$ |
| Impulse | $Ft = mv_2 - mv_1$ | Angular impulse | $\Gamma t = I\omega_2 - I\omega_1$ |

*Table 2.1 Analogy between linear and rotational motion*

**Competency level 2.6**: **Consumes and transforms mechanical energy productively**.

**No of periods**: 16

**Learning outcomes:**

Student will be able to:

- use the equations for work done, kinetic energy, potential energy and power to calculate energy changes and efficiencies.
- use principle of conservation of energy and the principle of conservation of mechanical energy.
- solve problems related to mechanical energy, power, work done and conservation of mechanical energy to analyze dynamic systems.

**Guidelines:**

- Terms ‘work’ and ‘energy’.
- Equations for
  - work done in linear motion, $W = FS$
  - work done in rotational motion, $W = \tau\theta$
- Various forms of mechanical energy and the equations for kinetic energy and potential energy.
  - Gravitational potential energy, $P.E._{gra} = mgh$
  - Elastic potential energy (Strain energy)

    $W = \frac{1}{2}Fe$ or $W = \frac{1}{2}kx^2$ where $k$ is the force constant.
  - Transnational kinetic energy, $K.E._{trans} = \frac{1}{2}mv^2$
  - Rotational kinetic energy, $K.E._{rot} = \frac{1}{2}I\omega^2$
- Principle of conservation of energy.
- The principle of conservation of mechanical energy
- Definition of the term ‘power’.

- The potential energy of an object is its stored ability to do work as a result of its position or shape.

- Usually a change in potential energy is required from some chosen zero. This might be sea level, or the floor or the lowest point of a swing, depending on the context.

**Suggested learning/teaching activities:**

- Show that the potential energy stored in a body of mass m when raised to a height in a gravitational field is given by $P.E._{gra} = mgh$

- Explain that the kinetic energy of an object is its stored ability to do work as a result of its motion. It can have translational kinetic energy as a result of its linear movement, and it may also have rotational kinetic energy as a result of rotation.

- Discuss example to explain the elastic potential energy.

- Considering a body falling freely in a gravitational field show that

  Kinetic energy + Potential energy = constant.

- Consider the motion of the bob of a simple pendulum to verify the validity of this principle.

**Competency level 2.7**: **Uses the principles and laws related to fluids at rest in scientific work and daily pursuits.**

**No of periods**: 14

**Learning outcomes:**

Student will be able to:

- solve problems related to comparison of densities with Hare's apparatus and U-tube.
- apply Pascal's principle to solve problems and to explain the working principle of hydraulic systems.
- use Archimedes' principle and principle of floatation to solve problems and to explain phenomena related to sinking and floating.

**Guidelines:**

- Density, relative density and pressure.
- Expression for hydrostatic pressure.
- Comparing densities of liquids using U-tube and Hare's apparatus.
- Pascal's principle and its applications.
- Up-thrust.
- Relationship between the apparent loss of weight and up-thrust.
- Archimedes' principle
- Principle of flotation.

**Suggested learning/teaching activities:**

- Define pressure.
- Explain that pressure is not a vector.
- Assign students to derive the relationship $p = h\rho g$ for the pressure inside a homogeneous liquid at rest.
- Explain Pascal's principle.
- Use Pascal's principle to describe the operating principle of a hydraulic jack.
- Discuss applications of Pascal's principle.
- Explain how the effect of pressure in a fluid gives rise to a buoyancy force on an object within the fluid and why bodies float.
- Determine what conditions must be met for an object to float.
- Discuss the properties of the pressure at a point inside the liquid.
- Use Hare's apparatus and U tube to compare densities of two liquids.
- Introduce up-thrust and state Archimedes' principle.
- Demonstrate Archimedes' principle using a suitable activity.
- Derive expression for Archimedes' principle.
- Discuss the principle of floatation.
- Use the simple hydrometer to find the density of liquids.

**Laboratory practical:**

- Comparing the relative density of liquids
  - using U- tube
  - using Hare's apparatus
- Comparing the density of liquids using the Hydrometer

**Competency level 2.8**: **Uses the principles and laws related to flowing fluids in scientific work and daily pursuits.**

**No of periods**: 08

**Learning outcomes:**

Student will be able to

- use the equation of continuity for a steady streamline flow.
- apply Bernoulli's principle to solve problems.

**Guidelines:**

- Steady flow -All the fluid particles that pass any given point follow the same path at the same speed.
- Turbulent flow - disorderly flow
- Line of flow – The path followed by a particle of the fluid
- Streamline is a curve whose tangent at any point is along the direction of the velocity of the fluid particle at that point. In steady flow, the streamlines coincide with the lines of flow.
- Laminar flow is a special case of steady flow in which the velocities of all the particles or any given streamline are the same, though the particles of different streamlines may move at different speeds.
- Non-viscous flow, equation of continuity, Bernoulli's principle and related effects.

Incompressible fluids
Something is regarded as incompressible if its volume does not change significantly when it is pressurized. Liquids are usually incompressible. Even though gases are obviously compressible, we can still use the Bernoulli's equation provided that the velocity of the object moving through the gas, or the velocity of the gas as it flows past an object is small compared with the velocity of sound through the gas.

- Equation of continuity for a steady flow
- Bernoulli's principle for the streamline flow and conditions.

**Suggested learning/teaching activities**:

- Demonstrate streamline non- turbulent and turbulent flows.
- Introduce the equation of continuity for a steady flow.
- Introduce and explain Bernoulli’s principle for the streamline flow of a non-viscous, incompressible fluid.
- Demonstrate Bernoulli's principle using apparatus available in the laboratory.
- Discuss situation where Bernoulli’s principle can be applied.

# Unit 3: Oscillations and Waves

**Competency 3.0**: **Uses the concepts and principles related to waves to broaden the range of sensitivity of human.**

**Competency level 3.1**: **Analyzes oscillations on the basis of physics.**

**No of periods**: 10

**Learning outcomes:**

Student will be able to:

- describe the conditions necessary for simple harmonic motion and calculate its period.
- relate the motion of an oscillating object to the forces acting on it.
- calculate the energy of a body in simple harmonic motion.

**Guidelines:**

- Simple harmonic motion as special case of oscillations.
- Terms ‘frequency’, ‘period’, ‘displacement’ and ‘amplitude’ of S.H.M.
- The characteristic equation for S.H.M.
  $a = -\omega^2 x$ .
- Representation of S.H.M. as a projection of uniform circular motion.
- Phase of oscillation.
- Phase difference of two oscillations.
- Displacement at a given time $y = A\sin\omega t$
- Relations $T = \frac{2\pi}{\omega}$, $f = \frac{1}{T}$, $\omega = 2\pi f$ , $v_{max} = A\omega$ and $a_{max} = -\omega^2 A$ where $\omega$ is a constant.
- Displacement vs time graph of a S.H.M.
- Small oscillations of a simple pendulum

  Period of oscillation, $T = 2\pi\sqrt{\frac{l}{g}}$

- Oscillations of a mass suspended light spring

  Period of oscillation, $T = 2\pi\sqrt{\dfrac{m}{k}}$

  $m$-mass
  $k$-spring constant

- Free, damped and forced oscillation.

- Resonance.

- Energy and energy transformations of a S.H.M. (*Table 3.1*)

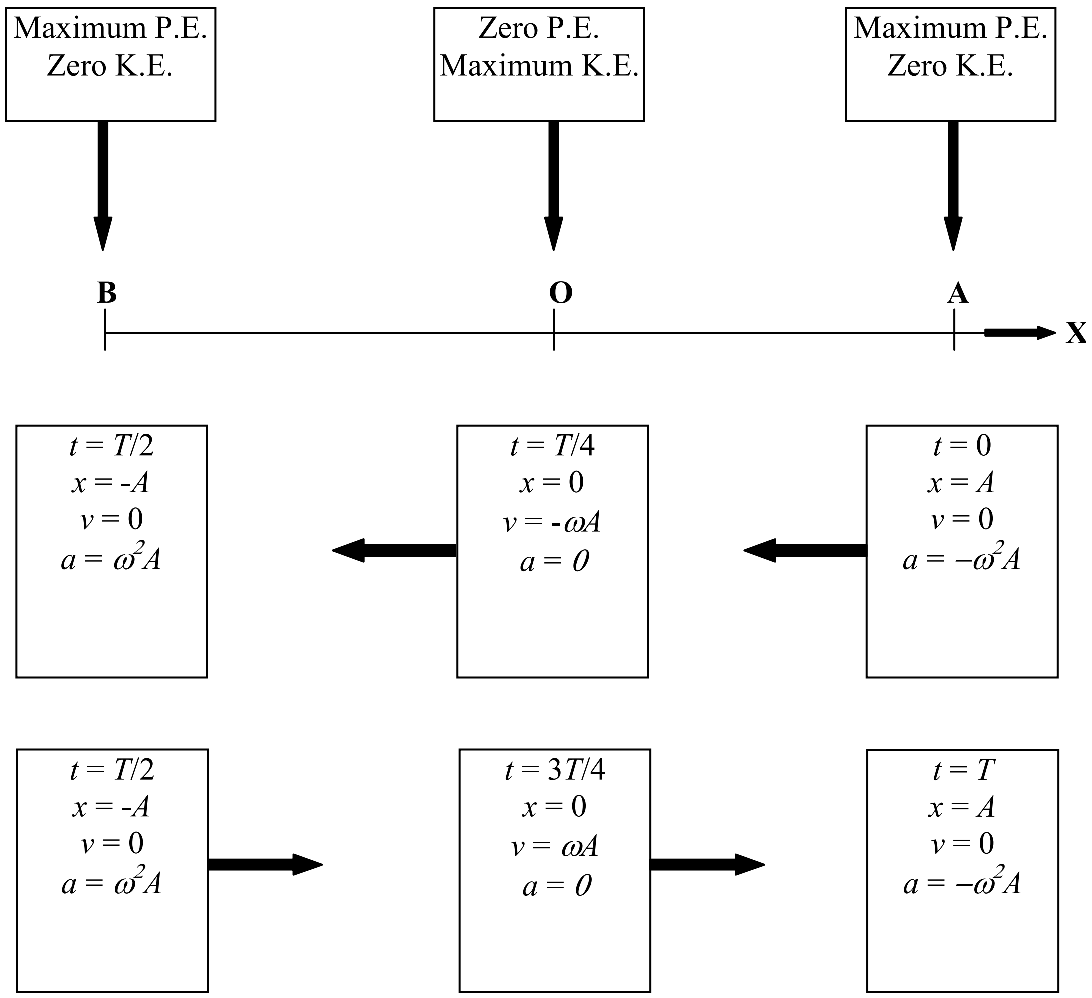



*Table 3.1 Energy and energy transformation in SHM*

**Suggested learning/teaching activities:**

- Observe an oscillating system such as a simple pendulum or a loaded spring to define displacement, amplitude, period and frequency of the oscillation.
- Discuss the energy transformations of an oscillating system.
- Define simple harmonic motion (S.H.M.)
- Show that the S.H.M. can be represented as a projection of a uniform circular motion.
- Discuss the usefulness of the above representation.
- Introduce the phase (angle) of the oscillation.
- Introduce the phase difference using two simple pendulums.
- Use the displacement-time graph to explain the nature of the S.H.M.
- Investigate the relationship between the length of a simple pendulum and its period of oscillation.
- Introduce free oscillations using damped oscillations using suitable activities.
- Use Barton's pendulums to demonstrate forced oscillations and resonance.
- Discuss several examples for mechanical resonance.
- Discuss the importance of the oscillations.

**Laboratory practical/demonstration:**

- Determination of gravitational acceleration by using simple pendulum
- Finding the relationship between the mass and the period
- Demonstration by Barton’s pendulums

**Competency level 3.2:** **Investigates various types of wave – motions and their uses**.

**No of periods**: 08

**Learning outcomes:**

Student will be able to:

- describe wave motion in terms of S.H.M. of particles.
- distinguish between longitudinal and transverse waves.
- represent the wave motion graphically and identify points in same phase (in phase) and different phase (out of phase).
- solve problems related to wave motion.

**Guidelines:**

- Transverse waves occur where the displacement is at right angles to the wave direction.
- Longitudinal waves occur where the displacement is along the line of the wave direction.
- Graphical representation of displacement of particles in a wave with distance at a given moment.
- Identifying the points in same phase (in-phase) and different phase (out of space).
- Wavelength with respect to points in same phase.
- Phase difference between two particles along the wave is the fraction of a cycle (angle in radians) by which one is behind the other.
- The terms, frequency ($f$), wavelength ( $\lambda$ ), speed ($v$), amplitude ($A$) and phase difference when applied to progressive waves.
- Frequency of the wave motion is the number of wave crests per second passing a given point.
- The speed of propagation of a wave to its frequency and wavelength as $v = f\lambda$ .
- Amplitude is the maximum displacement from equilibrium.

**Suggested learning/teaching activities:**

- Observe situations to gain an idea of waves as illustrated by vibrations in ropes, slinky springs or a ripple tank.

- Carry out activities using a ripple tank and a slinky spring or use computer simulations to demonstrate
  - that waves transfer energy without transferring matter.
  - transverse and longitudinal waves.

- Identify the characteristics of waves
  - transverse waves and longitudinal waves
  - frequency of the wave
  - amplitude, phase difference and wavelength

- Derive the relationship $v = f\lambda$

- Illustrate amplitude and period with the aid of a displacement-time graph for particles on the wave.

- Explain the graphical representations of the displacement of particles with distance in transverse and longitudinal waves.

- Explain the phase difference between two points in phase and two points out of phase at any instance in a wave.

- Define wavelength with respect to phase difference.

**Laboratory Demonstration:**

- Demonstration of wave motion using slinky/CRO

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

**No of periods:** 10

**Learning outcomes:**

Student will be able to:

- describe reflection, refraction, interference and diffraction as common properties of waves.
- use the principle of superposition of waves to explain the occurrence of
  - Interference
  - Stationary waves and
  - Beats
- carry out calculations on refraction, beats and stationary waves.

**Guidelines:**

- Reflection of waves
- Change in phase of a wave reflected at
  - a rigid boundary
  - a free boundary
- Refraction of waves
- Refractive index in terms of wave speed.
- Express refractive index with wave speed and wavelength ${}_1n_2 = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$
- Change of wavelength and speed of a wave when refraction occurs.
- The frequency of incident wave does not change when refraction occurs.
- Polarization.
- The principle of superposition of waves.
- Graphical representation of the resultant of two waves.
- Interference of waves using diagrams.
- Constructive and destructive interference.

- Forming of stationary waves.
- Conditions necessary for stationary waves.
- Properties of stationary waves.
- Graphical representation of the stationary waves.
- Formation of nodes and anti-nodes.
- Comparison of stationary waves and progressive waves.
- Occurrence of beats.
- Beat frequency $f_b = |f_1 - f_2|$

**Suggested learning/teaching activities:**

- Carry out activities to observe reflections of
  - Plane waves in a ripple tank
  - Sound waves
  - Waves in a rope
  - Waves in slinky
- Discuss the characteristics of the reflected wave in terms of the angle of reflection, wavelength, frequency, speed and direction of propagation in relation to the incident wave.
- Demonstrate rigid reflection and soft reflection using a slinky/spiral spring and explain the phase difference in two cases.
- View computer simulations of reflection of waves.
- Carry out activities to observe diffraction of water waves in a ripple tank / 3cm wave kit.
- Discuss the characteristics of the diffracted waves in terms of wavelength, frequency, speed, direction of propagation and shape of waves in relation to the incident wave.
- View computer simulations on diffraction of waves.
- Carry out activities to observe refraction of plane waves in a ripple tank./ 3 cm wave kit.
- Discuss the characteristics of the refracted wave in terms of the angle of refraction, wavelength, frequency, speed and direction of propagation in relation to the incident wave.

- Define refractive index.
- View computer simulations of refraction of waves.
- Observe a mechanical model such as a slinky spring or rope to gain an idea of superposition.
- State and discuss the principle of superposition.
- Carry out activities to observe interference patterns of water wave 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.
- Explain the conditions necessary for the production of a stationary wave.
- Describe graphically the formation of stationary waves.
- Demonstrate the formation of nodes and anti-nodes during the above activities.
- Predict and locate experimentally the nodes and anti-nodes using a microphone and CRO.
- Select two tuning 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.
- Derive the equation $f_b = f_1 - f_2$
- Carry out the following activity to demonstrate the stationary waves.
  - Place 1000 ml measuring cylinder horizontally and spread finely powdered cork in it.
  - Place a small speaker at the open end of the cylinder and feed it with an audio frequency signal generator.
  - Supply a frequency of about 3 kHz and observe the result of the stationary wave formed in air inside the tube.
- Explain the properties of a stationary wave.
- Describe the difference between stationary wave and progressive waves.

**Laboratory Demonstration:**

- Demonstration of properties of waves by ripple tank

**Competency level 3.4**: **Uses the modes of vibration of strings and rods by manipulating variables**.

**No of periods**: 12

**Learning outcomes**:

Student will be able to:

- explain the numerical patterns of resonant frequencies for stationary waves on strings and rods.
- use the knowledge of waves to describe seismic waves, formation of tsunami.
- carry out calculations on stationary wave patterns on strings and rods.

**Guidelines:**

- Transverse stationary waves in a string.
- Diagrams to explain the various modes of vibration in a stretched string.
- The simplest mode of vibration (fundamental) in a string.
- Over tones and harmonics in a string.
- Relationship between the length of the string and the wavelength for each mode of vibration.
- Formula for the speed of a transverse wave in a stretched string, $v = \sqrt{\frac{T}{m}}$
- Expression for the fundamental tone in a string.
- The formula for the speed of a longitudinal wave in a rod, $v = \sqrt{\frac{E}{\rho}}$
- Stationary waves formed in a rod
  - One end clamped
  - Clamped in the middle
- Working of vibrating strings instruments (some musical instruments).
- Seismic waves, Richter scale and Tsunami

**What is seismology?**

Seismology is the study of earthquakes and seismic waves that move through and around the earth.

**What are seismic waves?**

Seismic waves are the waves of energy caused by the sudden breaking of rock within the earth or an explosion. They are the energy that travels through the earth and is recorded on seismographs.

**Types of Seismic Waves**

There are several different kinds of seismic waves, and they all move in different ways. The two main types of waves are **body waves** and **surface waves**. Body waves can travel through the earth's inner layers, but surface waves can only move on surface of the earth.

**Body waves**

Travelling through the interior of the earth, **body waves** arrive before the surface waves emitted by an earthquake. These waves are of a higher frequency than surface waves.

**P waves**

The first kind of body wave is the **P wave** or **primary wave**. This is the fastest kind of seismic wave, and, consequently, the first to 'arrive' at a seismic station. The P wave can move through solid rock and fluids, like water or the liquid layers of the earth. It pushes and pulls the rock it moves through just like sound waves push and pull the air. Have you ever heard a big clap of thunder and heard the windows rattle at the same time? The windows rattle because the sound waves were pushing and pulling on the window glass much like P waves push and pull on rock. Sometimes animals can hear the P waves of an earthquake. Dogs, for instance, commonly begin barking hysterically just before an earthquake 'hits' (or more specifically, before the surface waves arrive). Usually people can only feel the bump and rattle of these waves.

P waves are also known as **compressional waves**, because of the pushing and pulling they do. Subjected to a P wave, particles move in the same direction that the wave is moving in, which is the direction that the energy is travelling in, and is sometimes called the 'direction of wave propagation'. *(Figure 3.1).* P waves are a kind of longitudinal wave.

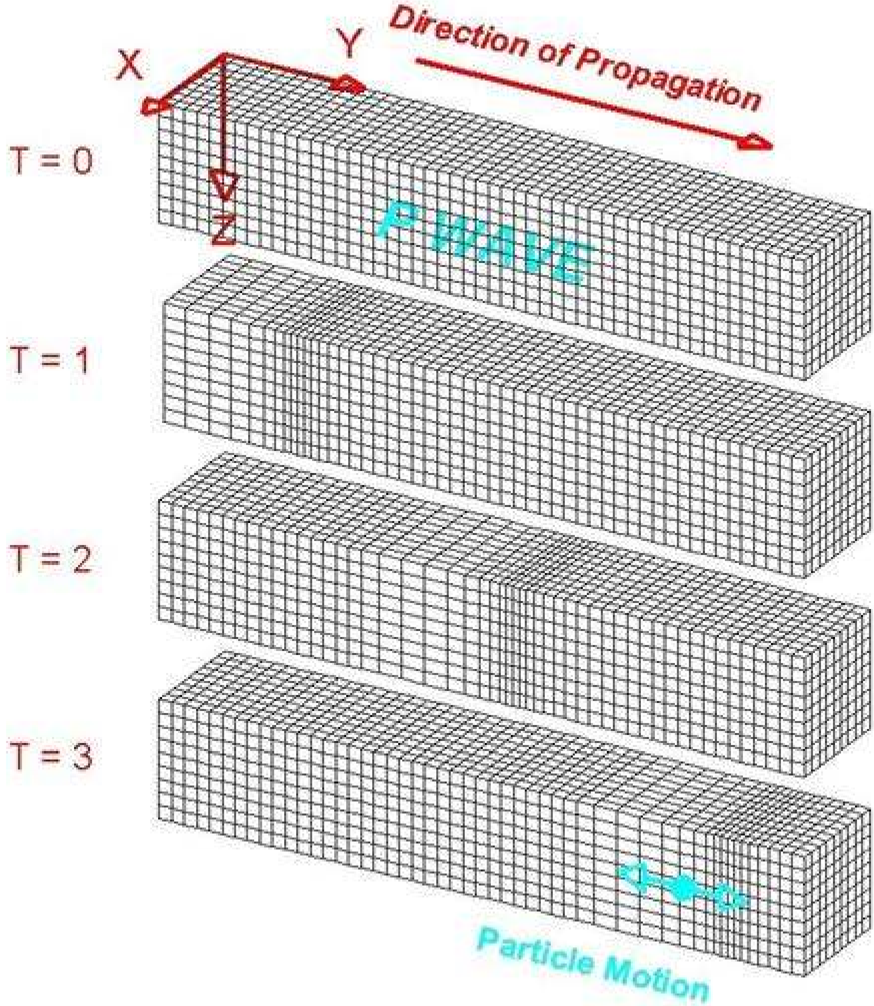



*Figure 3.1 Illustration of P waves*

**S waves**

The second type of body wave is the **S wave** or **secondary wave**, which is the second wave you feel in an earthquake. An S wave is slower than a P wave and can only move through solid rock, not through any liquid medium. It is this property of S waves that led seismologists to conclude that the Earth's **outer core** is a liquid. S waves move rock particles up and down, or side-to-side perpendicular to the direction that the wave is travelling in (the direction of wave propagation). *(Figure 3.2)* S waves are a kind of transverse wave.

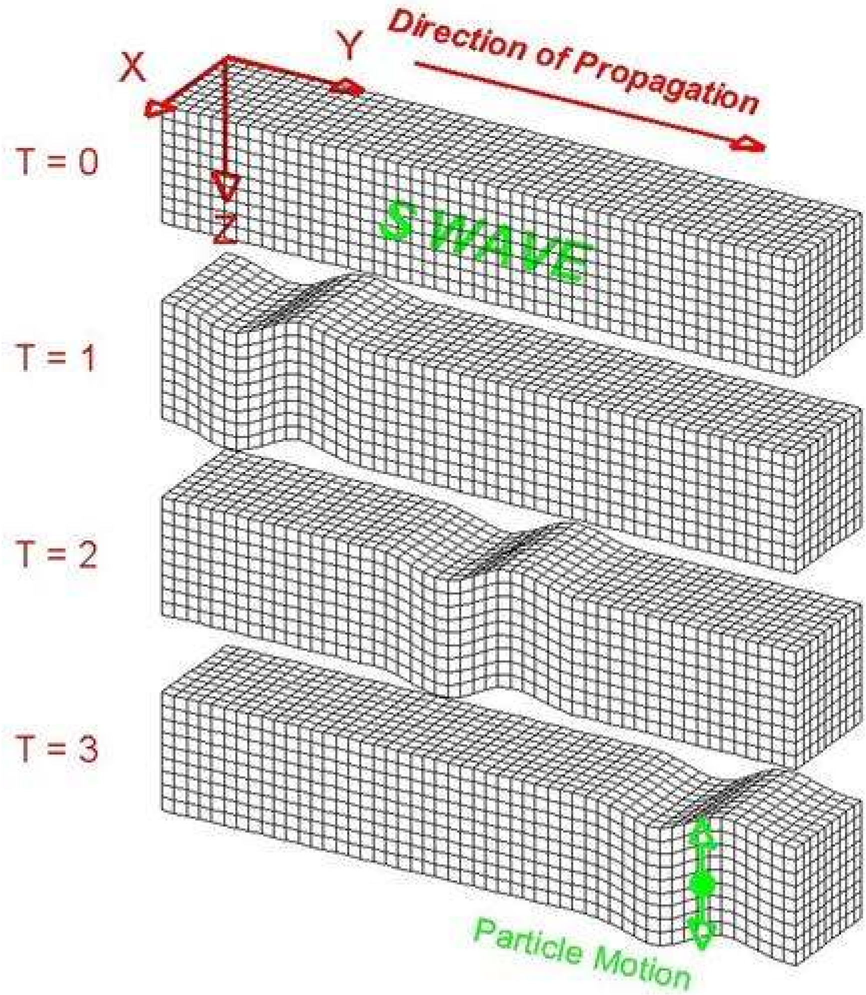



*Figure 3.2 Illustration of S waves*

## Surface waves

Travelling only through the crust, **surface waves** are of a lower frequency than body waves, and are easily distinguished on a seismogram as a result. Though they arrive after body waves, it is surface waves that are almost entirely responsible for the damage and destruction associated with earthquakes. This damage and the strength of the surface waves are reduced in deeper earthquakes.

## Richter scale

The Richter scale is the best known scale for measuring the magnitude of earthquakes. The magnitude value is proportional to the logarithm of the amplitude of the strongest wave during an earthquake. A recording of 7, for example, indicates a disturbance with ground motion 10 times as large as a recording of 6. The energy released by an earthquake increases by a factor of 30 for every unit increase in the Richter scale.

## Tsunami

A tsunami is a series of huge waves that can cause great devastation and loss of life when they strike a coast.

The word tsunami comes from the Japanese word meaning "harbor wave." Tsunamis are sometimes incorrectly called "tidal waves" .
Tsunamis are not caused by the tides (tides are caused by the gravitational force of the moon on the sea). Regular waves are caused by the wind.

Tsunamis are caused by
- an underwater earthquake,
- a volcanic eruption,
- an sub-marine rockslide,
- an asteroid or meteoroid crashing into in the water from space.

Most tsunamis are caused by underwater earthquakes. An earthquake has to be over about magnitude 6.75 on the Richter scale for it to cause a tsunami. About 90 percent of all tsunamis occur in the Pacific Ocean.

The Size of a Tsunami:
- Tsunamis have an extremely long wavelength (up to 100 km long)
- The period is also very long (about an hour in deep water)
- In the deep sea, a tsunami's height can be only about 1 m tall.

Tsunamis are often barely visible when they are in the deep sea. This makes tsunami detection in the deep sea very difficult.

The Speed of a Tsunami:
- over 970 km $h^{-1}$ in the open ocean (as fast as a jet flies)
- takes a few hours to travel across an entire ocean.

A regular wave (generated by the wind) travels at up to about 90 km $h^{-1}$.

Height of the tsunami:

- A tsunami may rise vertically up to 30 m.
- Most tsunamis cause the sea to rise 3 m.
- The last tsunami caused waves as high as 9 m in some places.

**Suggested learning/teaching activities:**

- Carry out suitable activities to demonstrate transverse waves.
- Give the equation $v = \sqrt{\frac{T}{m}}$ for the speed of transverse wave in a stretched string.
- Make the students do the experiment to observe stationary waves in a stretched string.
- Use the above experiment to show various modes of vibrations, identify overtones.
- Derive a relationship between the length of the string and wavelength for each mode of vibration.
- Derive the formula $T = \frac{1}{2l}\sqrt{\frac{T}{m}}$ for the fundamental tone in a string.
- Give the equation $v = \sqrt{\frac{E}{\rho}}$ for the speed of longitudinal wave in a medium.
- Describe fundamental vibration mode of a rod with one end clamped and with clamping in the middle.
- Demonstrate the relationship between vibrating length and the resonance frequency.
- Calculate the speed of longitudinal wave in a rod.
- Discuss briefly seismic waves, Richter scale and Tsunami

**Laboratory practical:**

- Finding the frequency of a tuning fork using vibrating string (sonometer).
- Finding the relationship between vibrating length and frequency.

**Competency level 3.5: Uses the vibrations in air columns by manipulating the variables.**

**No of periods:** 10

**Learning outcomes**:

Student will be able to:

- explain the numerical patterns of resonant frequencies for stationary waves in pipes (tubes).
- design experiments to determine the speed of sound in air and end correction using one tuning fork and set of tuning forks.
- carry out calculations on stationary waves in pipes.

**Guidelines:**

- Sound propagation through air.
- Equation $v = \sqrt{\frac{\gamma P}{\rho}}$ for the speed of a longitudinal wave in a gas.
- Equation $v = \sqrt{\frac{\gamma RT}{M}}$ to describe the effect of temperature and the molar mass on the speed of a sound wave in a gas.
- The speed of sound is not influenced by pressure when the temperature is constant.
- Methods to vibrate air in a tube (pipe).
- Stationary waves formed inside the tube.
- Modes of vibration in a tube closed at one end and open at both ends.
- Graphical representation of the modes of vibration.
- Relationship between wavelength and length of the tube for modes of vibration.
- End correction for the tube.
- Various states of resonance for the air columns in the tube.

**Suggested learning/teaching activities**:

- Explain that a longitudinal wave travels in a gas when a vibration is set up in the gas.

- State the speed of the wave is given by the equation $v = \sqrt{\dfrac{\gamma P}{\rho}}$

- Use ideal gas equation to derive the equation, $v = \sqrt{\dfrac{\gamma RT}{M}}$

- Explain that the speed of the wave is dependent on the temperature.

- Explain that the speed of the wave is independent of its pressure at constant temperature.

- Solve problems related to speed of sound in gases.

- Set up vibrations in air columns in open tubes and tubes closed at one end.

- Explain that the stationary wave is formed due to superposition of incident and reflected waves.

- Find the relative positions of nodes and anti-nodes using a suitable activity.

- Illustrate the wave graphically relative to the length of the tube.

- Use the relative positions of nodes and anti-nodes to derive the relationship between wavelength and length of the tube.

- Explain the end correction for the tube.

- For a given tuning fork, find the fundamental and the first overtone positions of resonance.

**Laboratory experiment:**

- Determination the speed of sound in air using a closed tube
    - by one tuning fork
    - by a set of tuning forks (graphical method)

**Competency level 3.6**: **Inquires about the uses of Doppler effect.**

**No of periods:** 04

**Learning outcomes:**

Student will be able to:

- apply the Doppler effect to sound with appropriate calculations.
- describe phenomena related to change in apparent frequency using Doppler effect.

**Guidelines:**

- Doppler effect
- Change in frequency
  - when the source moves.
  - when the observer moves.
  - when both source and observer move.
- Equations $f' = (\frac{v \pm v_0}{v \mp v_s})f$
- Sonic Boom.

**Supersonic speeds; Shock waves**

If a source is moving toward a stationary detector at a speed equal to the speed of sound - that is, if $v_s = v$ - the equations, $f' = f\frac{v \pm v_D}{v \mp v_S}$ and $f' = f\frac{v}{v \pm v_S}$ predict that the detected frequency $f'$ will be infinitely great. This means that the source is moving so fast that it keeps pace with its own spherical wavefronts as *Figure 3.3 (a)* suggests. What happens when the speed of the source exceeds the speed of sound?

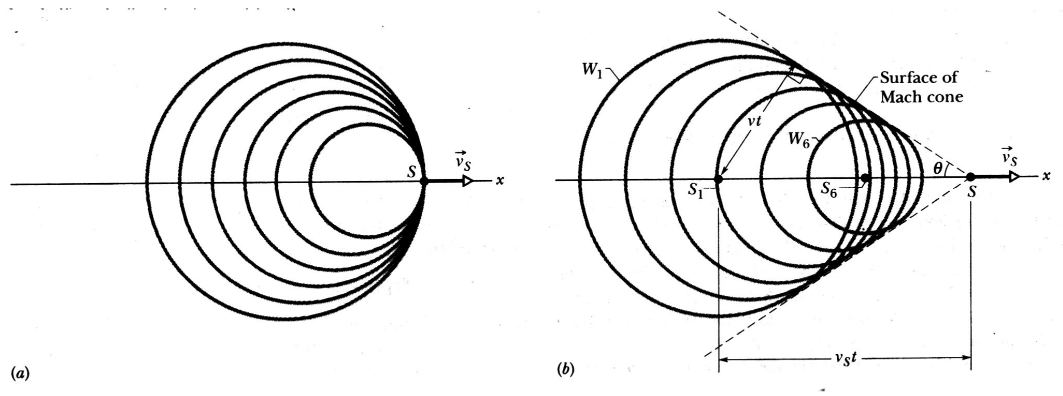



*Figure 3.3(a) A source of sound S moves at speed $v_S$ equal to the speed of sound and thus as fast as the wavefront it generates. (b)A source S moves at speed $v_S$ faster than the speed of sound and thus faster than the wavefronts. When the source was at position $S_1$ it generated front $W_1$, and at position $S_6$ it generated $W_6$. All the spherical wavefronts expand at the speed of sound $v$ and bunch along the surface of a cone called the Mach cone, forming a shock wave.*

For such supersonic speeds, above equations no longer apply. *Figure 3.3 (b)* depicts the spherical wavefronts that originated at various positions of the source. The radius of any wavefront in this figure is $vt$, where $v$ the speed of sound is and t is the time that has elapsed since the source emitted that wave front. Note that all the wavefronts bunch along a V-shaped envelope in then two-dimensional drawing of *Figure 3.3(b)*. The wavefronts actually extend in three dimensions, and the bunching actually forms a cone called the Mach cone. A shock wave is said to exist along the surface of this cone, because the bunching of wavefronts causes an abrupt rise and fall of air pressure as the surface passes through any point.

The shock wave generated by a supersonic aircraft (*Figure 3.4*) or projectile produces a burst of sound, called a sonic boom, in which the air pressure first suddenly increases and then suddenly decreases below normal before returning to normal. Part of the sound that is heard when a rifle is fired is the sonic boom produced by the bullet. A sonic boom can also be heard from a long whip when it is snapped quickly: Near the end of the whip's motion, its tip is moving faster than sound and produces a small sonic boom-the crack of the whip.

*Figure 3.4 Shock waves produced by the wings of a Navy FA 18 jet. They are visible because the sudden decrease in air pressure in the shock waves caused water molecules in the air to condense, forming a fog.*

**Suggested learning/teaching activities**:

- Explain the Doppler effect using 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 how the frequency heard by a stationary observer changes when a vehicle sounding the whistle passes him.
- Explain using illustrations how the change in frequency as heard by an observer traveling in a vehicle when he passes a stationary source of sound.
- Explain using illustrations how the change in frequency as heard by an observer when both the source of sound and observer are moving.
- Assign students to demonstrate Doppler effect using two identical tuning forks fixed to two wooden boxes. Vibrate both the tuning forks. Keep one stationary and move with the other towards the wall. Then beats can be heard.
- Assign students to demonstrate Doppler effect using the ripple tank.
- Assign students, research and report on applications and explanations of phenomena using Doppler effect.
- Explain briefly the Sonic Boom.
- Explain equations for apparent frequency, $f' = (\frac{v \pm v_0}{v \mp v_s})f$

$v$ - speed of sound
$v_0$ - speed of observer
$v_s$ - speed of source
$f'$ - apparent frequency
$f$ - real frequency

**Competency level 3.7:** **Produces and propagates sound by considering characteristics of sound.**

**No of periods:** 08

**Learning outcomes:**

Student will be able to:

- describe the characteristic properties of sound.
- use the graph of intensity level verses the frequency for human ear to explain various situations.
- carry out calculations related to intensity level (decibel) and intensity.

**Guidelines:**

- Property named pitch and its relationship to frequency.
- Quality of sound and its relationship to the waveform.
- Loudness and its relationship to the amplitude.
- Relationship between the intensity of sound and the amplitude of sound wave.
- Threshold of hearing.
- Threshold of pain.
- Intensity levels of sound (decibel).
- Uses of ultrasonic waves.
- Uses of infrasonic waves.
- Applications of ultrasonic and infrasonic.

**Graph of intensity level of sound versus the frequency of the sound for a human ear.**

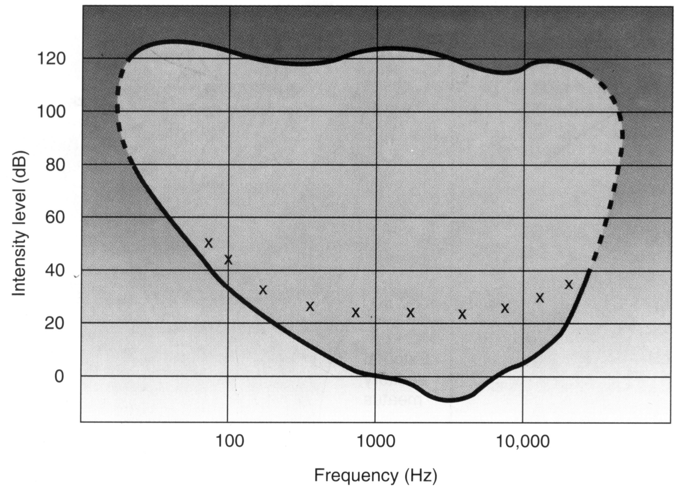



*Figure 3.5 Intensity level of sound versus the frequency of the sound for a human ear.*

The human ear is responsive to a large range of frequencies and intensities. A typical response curve is shown in *Figure 3.5*. The intensity level of sound is plotted against the frequency of the sound. The continuous curved line at the bottom represents the response curve of a normal ear. The lowest region on the curve occurs from about 1000 Hz to about 4000 Hz. These frequencies can be heard by the normal ear at very low intensity level. On the other hand, to hear a frequency of 100 Hz the intensity level would have to be increased to about 35 dB. And for a normal ear to hear a frequency of about 20,000 Hz the intensity level would have to be increased to about 40 dB. At an intensity of 20 dB a frequency of 1000 Hz can easily be heard, but a frequency of 100 Hz could not be heard at all.

With age the frequencies that the human ear can hear decreases. Many people resort to a hearing aid to overcome this hearing deficiency? A test is made of the person's ability to hear a sound of known intensity level and frequency. The person is placed in a soundproof booth and earphones are placed over his or her ears. The examiner then plays pure sounds at a known frequency. He or she starts at a low intensity level and increases the intensity in small steps until the individual hears that particular frequency. When the individual hears the sound, he or she presses a button to let the examiner know that he or she has heard the sound. The examiner then marks an x on the graph of the frequency and intensity level of the normal ear shown in the figure. The x's represent the actual frequencies heard at a particular intensity level. By knowing the frequencies that the person can no longer hear very well, a hearing aid, which is essentially a miniature electronic amplifier, is designed to amplify those frequencies, and thus bring the sound of that frequency up to a normal intensity level for that individual. For example the x's in the figure indicate that the individual's hearing response has deteriorated. In particular, the hearing response in the midrange frequency is much worse than at the low end or the high end of the spectrum. (The x's in the midrange are farther away from the normal curve). Thus a hearing aid that amplifies the frequencies in the middle range of the audio spectrum would be useful for the individual. We would certainly not want to amplify the entire audio spectrum, for then we would be amplifying some of the frequencies that the person already hears reasonably well.

It is interesting to note that not only humans use sounds to communicate but animals do also. Some animals communicate at a higher frequency than can be heard by humans. These sounds are called ultrasonic and occur at frequencies above 20,000 Hz. Birds and dogs can hear these ultrasounds and bats even use them for navigation in a kind of sound radar. Ultrasound is used in sonar systems to detect submarines. It is also used in a variety of medical applications, including diagnosis and treatment. For example, chiropractors and physical therapists routinely use ultrasound for relief of lower back pain.

**Suggested learning/teaching activities:**

- Introduce characteristic properties of sound.
- Carry out activities to observe the effect of
  - amplitude on loudness
  - frequency on pitch
- Use CRO and various musical instruments to demonstrate the quality of sound.
- Explain reasons for the quality of sound.
- Explain the threshold of hearing and threshold of pain for human ear and give values of sound intensity.
- Define decibel as the unit for measuring the intensity level of sound.
- Discuss simple problems.
- Introduce ultrasonic and infrasonic qualitatively.
- Assign students explore and report on applications of the ultrasonic and infrasonic.

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

**No of periods:** 04

**Learning outcomes:**

Student will be able to:

- describe the properties and applications of electromagnetic waves in each of the main wavelength ranges.

**Guidelines:**

- Properties of electromagnetic waves.
- Graphical representation of an electromagnetic wave.
- Instances where electromagnetic waves are produced naturally and practically.
- Various waves in electromagnetic spectrum.
- Applications of electromagnetic waves.
  - Radio waves in broadcasting and communications
  - Micro waves in satellites and cellular phones
  - Infra-red rays in household appliances, remote controls and night vision devices
  - Visible light in optical fibers and photography
  - Ultra-violet rays in fluorescent lamps and sterilization
  - X-rays in medical and engineering applications
  - Gamma rays in medical treatment
- Action of LASER
  - Absorption
  - Spontaneous emission.
  - Stimulated emission
- Properties and uses of LASER beams.
- Light travels in the form of a wave.
- Light wave can be considered as a ray.

## Lasers

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

(a) Action.
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.*

*Figure 3.6*
*Spontaneous emission*

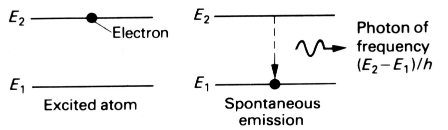
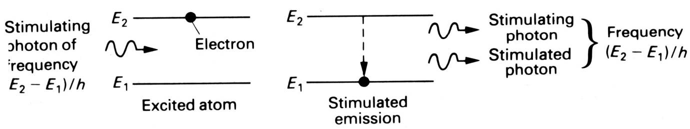



*Figure 3.7*
*Stimulated emission*




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 illuminating 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 starts 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 o the stimulated radiation.

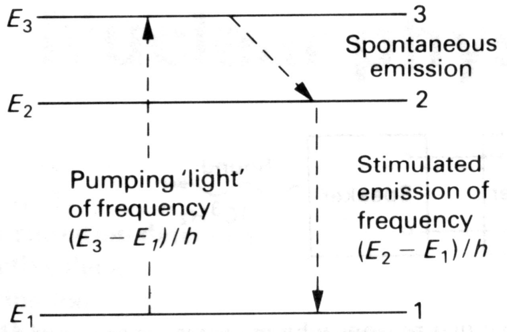



*Figure 3.8 Action of Laser in a three level system*

(b) *Ruby Laser*

Many materials can be used in laser. The ruby rod laser consists of a synthetic crystal of aluminium oxide containing a small amount of chromium as the laser material. It is a type of three-level leaser in which 'level'3 consists of a band of very close energy levels. The pumping radiation, produced by intense flashes of yellow-green light from a flash tube, *Figure 3.9*, raises electrons from level 1 ( the ground level) into one of the levels of the band. From there they fall spontaneously to the metastable level 2 where they can remain for approximately 1 millisecond, as compared with $10^{-8}$ second in the energy band. Red laser light is emitted when they are stimulated to fall to level 1 from 2. One end of the ruby rod is silvered to act as a complete reflector whilst the other is thinly silvered and allow partial transmission. Stimulated light photons are reflected to and fro along the rod producing an intense beam, part of which emerges from the partially silvered end as the useful output of the laser.

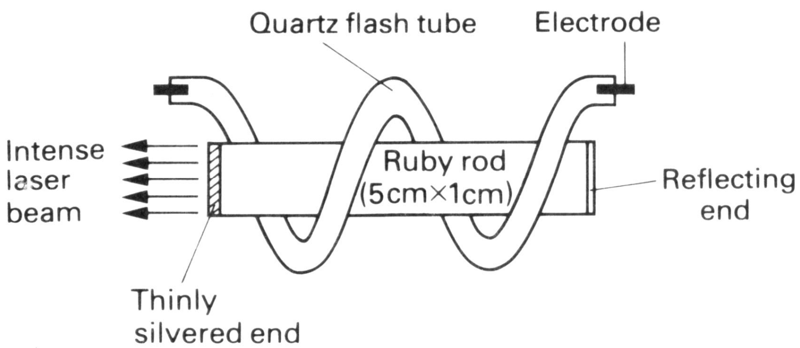



*Figure 3.9 Ruby laser*

(c) Helium – neon laser.

This uses a mixture of helium and neon, and whereas the ruby laser emits short pulses of light, it works continuously and produces a less divergent beam. In one form the gas is in a long quartz tube with an optically flat mirror at each end. Pumping is done by a 28 M Hz r.f. generator instead of a flash tube. An electric discharge in the gas pumps the helium atoms to a higher energy level. They then excite the neon atoms to a higher level by collision and produce an inverted population of neon atom which emit radiation when they are stimulated to fall to a lower level.

(d). *Uses*.
Semiconductor lasers are used in optical fibre communication systems. Ruby lasers are used for range finding, welding, drilling and microcircuit fabrication. Helium-Neon lasers are used for the precision measurement of length, surveying, printing and holography.

**Suggested learning/teaching activities**:

- Introduce the electromagnetic wave and explain that this wave consists of oscillating electric and magnetic fields.
- Illustrate the electromagnetic wave graphically.
- Give instances where the electromagnetic waves are produced naturally and practically.
- Explain that the speed of all electromagnetic waves is a constant ($3x10^8$ m $s^{-1}$) in vacuum.
- Assign students to explore and report on the components of the electromagnetic spectrum in terms of decreasing wavelength or increasing frequency.
- Discuss the properties of electromagnetic waves.
- Discuss briefly the applications of the electromagnetic waves.
- Explore the action, properties and uses of LASER.
- Stress the safety precautions should be followed in handling lasers.

**Competency level 3.9:** **Applies the principles of refraction of light for daily pursuits.**

**No of periods:** 12

**Learning outcomes**:

Student will be able to:

- design experiments to determine images formed due to refraction.
- carry out calculations on refraction at plane boundaries and total internal reflection.
- carry out calculations for lens and combination of lenses

**Guidelines:**

- Refraction, the laws of refraction and refractive index.

Optical density has no connection with mass/volume. The optical density of a transparent material is related only to the speed through it. The more optically dense the material, the slower light travels through it.

- Absolute refractive index and relative refractive index.
- Relationship between refractive indices ${}_1n_2 = n_2 / n_1$.
- Relationship, $n = \frac{\text{real depth}}{\text{apparent depth}}$ and use it to find refractive index of glass.
- Relationship for apparent displacement, $d = t(1 - \frac{1}{n})$
- Critical angle and conditions under which total internal reflection occurs.
- Applications of total internal reflection.
- Relationship between critical angle and refractive index $n = \frac{1}{\sin C}$
- Refraction of light through a prism and deviation.
- Minimum deviation and relationship $n = \frac{\sin(\frac{A + D_{min}}{2})}{\sin \frac{A}{2}}$

- Relation between deviation, angle of incidence and angle of refraction,

  $d = (i_1 + i_2) - A$

- Spectrometer and the main adjustments of spectrometer.

- Refraction through a lens.

- Focus and focal length of a lens.

- Real and virtual images formed by convex and concave lenses.
  - experimental method
  - ray diagrams

- Lens formula with sign convention to determine real and virtual images.

- Linear magnification of an image.

- Power of a lens.

- Equation of lens combination.

**Suggested learning/teaching activities**:

- Explain the phenomena of refraction, condition for refraction and laws of refraction
- Define refractive index (absolute and relative)
- Carry out activities to demonstrate apparent depth, displacement and derive expression for them.

- Describe critical angle and total internal reflection using ray diagrams.
- Derive $n = \frac{1}{\sin C}$
- Describe refraction through a prism using ray diagrams and doing an experiment.
- Assign students to find the variation in angle of deviation with the angle of incidence and to interpret graphically.

- Introduce the state of minimum deviation.

- Demonstrate the main adjustments of spectrometer and explain reasons.

- Introduce the focus and focal length of a lens and direct students to construct the images, using ray diagrams.

- Use geometrical method to derive lens formula with Cartesian sign convention.
- Predict the characteristics of real and virtual images
    - Algebraically – using lens formula
    - Geometrically – using ray diagrams
    - Verify experimentally

- Introduce the equation for the lens combination

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

**Laboratory experiment:**

- Finding refractive index using traveling microscope

- Experimental investigation of deviation through prism

- Finding the refractive index of the prism material by critical angle method

- Spectrometer
    - Main adjustments of the spectrometer
    - Finding the angle of prism
    - Finding the angle of minimum deviation

- Determination of real and virtual images of lenses (no-parallax method).

**Competency level 3.10**: **Applies the knowledge of images formed by lenses for the correction of defects of vision appropriately.**

**No of periods**: 04

**Learning outcomes**:

Student will be able to:

- describe optical system of human eye.
- carry out sight correction calculations.

**Guidelines:**

- Define angle of vision.
- Far point and near point.
- Formation of image on retina.
- Short sight (myopia), long sight (hypermetropia) and their corrections.

**Suggested learning/teaching activities**:

- Define angle of vision using ray diagrams.
- Introduce the main features of an eye using a diagram.
- Explain short sight and long sight using ray diagrams and describe methods used to correct those defects.

**Competency level 3.11: Applies the knowledge of the images formed by lenses in using the optical instruments appropriately.**

**No of periods**: 04

**Learning outcomes**:

Student will be able to:

- sketch ray diagrams to explain how a simple and compound microscope work and carry out related calculations.
- sketch ray diagrams to explain how astronomical telescopes work and carry out related calculations.

**Guidelines:**

- Normal adjustment of a simple microscope using ray diagrams and the expression for angular magnification
- Normal adjustment of a compound microscope using ray diagrams and the expression for the angular magnification.
- Normal adjustment of an astronomical telescope using ray diagrams and the expression for the angular magnification.
- Ray diagrams for instances where microscopes and telescopes are not in the normal adjustment.

**Suggested learning/teaching activities**:

- Assign student to use a converging lens as a magnifying glass.
- Explain the simple microscope using ray diagrams.
- Derive an expression for angular magnification.
- Demonstrate how to use compound microscope.
- Explain the compound microscope in normal adjustment using ray diagrams.
- Derive an expression for angular magnification.
- Assign student to use an astronomical telescope.
- Explain the astronomical telescope in normal adjustment using ray diagrams.
- Derive an expression for angular magnification.
- Discuss instances where microscopes and telescopes are not in normal adjustment.

# Unit 4: Thermal Physics

**Competency 4.0:** **Uses the knowledge of heat to fulfil human needs and for scientific work productively.**

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

**No of periods** **:** 04

**Learning outcomes:**

Student will be able to:

- explain the different temperature scales and different types of thermometers.
- relate and use Kelvin and Celsius temperature scales.

**Guidelines:**

- The condition for heat flow considering thermal equilibrium between bodies.
- The zeroth law of thermodynamics.
- The term 'temperature.'
- Some properties, which vary with temperature and the essentials of thermometric properties.

The **thermodynamic scale** is the one that is used for scientific measurement. It is measured in units called **kelvin (K)**, the temperature itself being given the letter T. It is defined using one fixed point – the **triple point** of water. This is the temperature where saturated water vapour, pure water and ice are all in equilibrium at 273.16 K.

The **Celcius scale** is now defined by $\theta = T - 273.15$. The two fixed points on this scale are the ice point (0 $^0$C) and the steam point (100 $^0$C). The ice point and the triple point differ by 0.01K.

A temperature scale depends on the particular property on which it is based. In setting up a scale of temperature we must:

(a) choose a property that varies with temperature,
(b) assume that it varies uniformly with temperature.

- Equation for temperature based on two fixed points

$$\theta = \frac{x_\theta - x_L}{x_H - x_L}(\theta_H - \theta_L) + \theta_L$$

- Equation for absolute temperature based on triple point of pure water.

$$T = \frac{X_T}{X_{tr}} \times 273.16$$

- Relationship between Celsius and absolute temperature

$$T = \theta + 273.15$$

**Thermistors**

These devices like resistance thermometers rely on their change of electrical resistance with temperature as a means of measuring temperature. Unlike resistance thermometers, however, they have negative temperature coefficients of resistance; their resistance decreasing approximately exponentially with increasing temperature. Thermistors are semiconducting devices cheaply manufactured out of several different mixtures of semiconducting oxide powders ($Fe_3O_4$ + $MgCr_2O_4$ is a common mixture). They are very robust. When a Wheatston bridge circuit is used to measure their resistance, they are about twenty times as sensitive as resistance thermometers. The resistance of connecting wires is of no significance, since the devices themselves typically have a resistance of 1 $k\Omega$. Thermistors have very small thermal capacities, and therefore respond quickly and have little effect on the temperature they are measuring. The range is typically -70 $^0$C to 300 $^0$C. They are less stable than resistance thermometers, and therefore less accurate.

**Suggested learning/teaching activities:**

- Assign students to do suitable activities to understand the basic requirements for heat flow from one body to another.

- When heat flows between bodies of different hotness, explain what is meant by a state of thermal equilibrium and extend the discussion to explain the zeroth law of thermodynamics.

- By discussion develop the idea that a system of bodies are in thermal equilibrium when they are at equal temperature and net thermal flow is zero.

- Do activities to tabulate some properties, which vary with temperature. (e.g. Fix a narrow glass tube to a boiling tube. Trap some air in it by means of a pellet of mercury in the tube and demonstrate the variation of the volume of air with temperature.)

- Obtain the essentials of thermometric properties by discussion.
  The property should be
    a single valued function and
    a continuous function.

- Assuming that the variation of thermometric property with temperature is linear, draw the graph of thermometric property vs. temperature.

- Explain the necessity of fixed points for this scale.

- Explain the Celsius temperature scale.

- Introduce the absolute scale of temperature based on the triple point of water and the expressions

  $$T = \frac{X_T}{X_{tr}} \times 273.16$$

  $$T = \theta + 273.15$$

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

**No of periods** : 06

**Learning outcomes:**

Student will be able to:

- calculate thermal expansion and describe related applications.
- explain phenomena related to anomalous expansion of water.

**Guidelines:**

- Length, area and volume of a solid object increase when its temperature is increased.
- Linear, area and volume expansivities and state the relationship between them.
- Liquids have only volume expansion.
- Relationship between the absolute expansivity, apparent expansivity of a liquid and the volume expansivity of container.
- The equation for density in terms of temperature and volume expansivity (absolute).
- The expansion of water is different from normal liquids for a particular range of temperature.
- Graphical representation of the variation of volume and density of water with temperature.
- Use the definitions of linear, area and cubic expansivities to obtain the equations.
  $l_2 = l_1(1+\alpha\theta), A_2 = A_1(1+\beta\theta), V_2 = V_1(1+\gamma\theta)$
- The relationship for densities.
  $d_\theta = \dfrac{d_0}{(1+\gamma\theta)}$

**Suggested learning / teaching activities:**

- Use a simple experimental set up to show that the length of a wire or a rod increases when the temperature is increased.
- By discussion develop the idea that length, breadth and thickness increase with temperature and the volume and area also increase.
- Explain that the expansion of a given rod is proportional to the temperature difference and the length of the rod. And define linear expansivity for the material of the rod.
- Introduce area expansivity and volume (cubic) expansivity and relate with linear expansivity.
- Discuss the effects and uses of solid expansion.
- Use the definitions of linear, area and cubic expansivities to obtain the equations.
  $l_2 = l_1(1+\alpha\theta), A_2 = A_1(1+\beta\theta), V_2 = V_1(1+\gamma\theta)$
- Use a simple experimental set up to show that the volume of a liquid increases with temperature.
- Explain absolute expansion and apparent expansion of a liquid using a suitable activity.
- Derive the relationship between the absolute expansivity and apparent expansivity.
- Discuss the variation of density with temperature.
- Obtain the relationship for densities.
  $$d_\theta = \frac{d_0}{(1+\gamma\theta)}$$
- Describe the anomalous expansion of water with the help of simple activity and discuss the importance of it.
- Describe the variation of volume and density of water with temperature and illustrate them graphically.

**Competency level 4.3: Investigates the behaviour of gases using gas laws**.

**No of periods** **:** 08

**Learning outcomes:**

Student will be able to:

- demonstrate gas laws experimentally and explain the ideal gas equation.
- make calculations using the ideal gas equation and gas laws.

**Guidelines:**

- Boyle's law.
- Charles's law.
- The pressure law.
- The concept of an ideal gas.
- Ideal gas equation.
- Dalton's law of partial pressure.

**Suggested learning / teaching activities:**

- Explain the relationship between the pressure, volume and temperature of a fixed mass of air.
- Describe and explain gas laws.
- Derive the ideal gas equation.
- Explain Dalton's law of partial pressure.

**Laboratory practical:**

- Finding the atmospheric pressure using quill tube.
- Investigation of the relation between volume and temperature of a gas at constant pressure.
- Investigation of the relation between pressure and temperature of a gas 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:**

Student will be able to:

- relate temperature to the mean kinetic energy of molecules of a gas.
- make calculations using the kinetic theory equation.

**Guidelines:**

- The distribution of molecular speeds within a gas (qualitatively).
- The basic assumptions of the kinetic theory of gases.

  1. Any gas consists of very large number of molecules.
  2. The molecules of the gas are in rapid, random motion.
  3. Collisions between gas molecules are elastic.
  4. Collisions between gas molecules and the walls of the container are elastic.
  5. There are no intermolecular attractive forces.
  6. Inter-molecular forces of repulsion act only during collisions between molecules.
  7. The volume of the gas molecules themselves is negligible compared with the volume of the container, i.e., almost all the gas is empty space.

- The kinetic theory of an ideal gas.
- The distributions of molecular speeds and root mean square speed.
- Presenting the equation $pV = \frac{1}{3}Nm\overline{c^2}$
- The pressure exerted by a gas $p = \frac{1}{3}\rho\overline{c^2}$

  and the mean square speed $\overline{c^2} = \frac{3RT}{M}$
- Mean kinetic energy of a gas molecule $E = \frac{3RT}{2N_A}$ , $\frac{R}{N_A} = k$ , Boltzmann constant

The behaviour of a gas on a macroscopic scale concerns the variation of its temperature, volume and pressure. But to obtain a clearer understanding of gas behaviour, we must be able to relate the microscopic movement of the individual gas molecules to these macroscopic quantities. It is the kinetic theory that enables this to be done. As usual, any theory must be able to be checked by experiment and must provide greater understanding of the physical problems. The kinetic theory of gases applies the laws of mechanics to molecular movement, so that expressions for the pressure and temperature of a gas are obtained in terms of molecular speed, mass and number.

In solving problems using the kinetic theory of gases, extra care must be taken with algebraic symbols and units.
Temperature will always be in kelvin.
Relative molecular mass has no units.
Molar mass is the mass of a mole and will be quoted in kg mol$^{-1}$

For example,

| | |
|---|---|
| Relative atomic mass of oxygen | = 16 |
| Relative molecular mass of oxygen | = 32 |
| Molar mass of oxygen atom | = 0.016 kg mol$^{-1}$ or 16 g mol$^{-1}$ |
| Molar mass of oxygen molecules | = 0.032 kg mol$^{-1}$ or 32 g mol$^{-1}$ |
| Mass of oxygen atom | $= \dfrac{0.016}{6.02 \times 10^{23}}$ kg |

**Suggested learning / teaching activities:**

- Explain how pressure is exerted by a gas.
- Using the equations, $pV = \frac{1}{3} Nm\overline{c^2}$ and $pV = nRT$

  Deduce the equations, $p = \frac{1}{3}\rho\overline{c^2}$ , $\overline{c^2} = \frac{3RT}{M}$ and $E = \frac{3RT}{2N_A}$
- Describe assumptions of the kinetic theory of gases.

**Competency level 4.5:** Quantifies the amount of heat exchange among the objects using the specific heat capacity of substances.

**No of periods:** 06

**Learning outcomes:**

Student will be able to:

- carry out calculations and measurements of the specific heat capacities of materials.
- use Newton's law of cooling to carry out calculations on heat dissipation.

**Guidelines:**

- When heat is supplied to matter, if no change of state takes place, the temperature varies.
- When the temperature of a body is varied, the amount of heat exchanged by the body varies.
- The heat capacity of a body
- The specific heat capacity of a substance (solid and liquid).
- The equation $\Delta Q = mc\Delta\theta$ for the amount of heat exchanged.
- The methods of losing heat to the surrounding and precautions to reduce the heat loss
- Newton's law of cooling
- Molar heat capacities of a gas at constant pressure and at constant volume
- The ratio $\gamma = \frac{C_p}{C_V}$ depends on the atomicity of the gas.

**Suggested learning / teaching activities:**

- Assign students to carry out the following activity.
  Heat the same body to different temperatures and drop it into identical calorimeters containing the same amount of water and show that they attain different final temperatures.

- By discussion, show that the net amount of heat exchanged is proportional to change in temperature and define heat capacity of a body.

- Define the specific heat capacity of a substance.

- By discussion, show that the change in the amount of heat of the body is given by $Q = mc\theta$

- Define the molar heat capacities of a gas.

- Discuss the methods by which heat is lost and methods to reduce the heat lost and how a correction for heat loss is obtained by changing the initial temperature.

- Assign students to carry out simple activities to show the difference between the cooling of a hot body under natural convection and forced convection.

- Obtain a correction for heat loss by changing the initial temperature.

- State and describe Newton's law of cooling and explain limits.

**Laboratory practical:**

- Determination of specific heat capacities of solids and liquids by the method of mixtures
- Comparison of specific heat capacities of liquids 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:** 06

**Learning outcomes:**

Student will be able to:

- carry out calculations and measurements of the latent heat of materials.

**Guidelines:**

- The difference between solids, liquids and gases by considering the volume and the shape
- In all forms of matter, the molecules / particles are held together by bonds.
- The basic particles, which constitute a substance, have kinetic energy and potential energy.
- Absorption or emission of energy takes place when change of state takes place.
- When the solid absorbs energy, the binding forces between molecules decreases and the solid changes into liquid.
- Vapourization with reference to molecular bahaviour
- When heat is supplied to matter, if a change of state takes place the temperature remains constant.
- The specific latent heat of fusion
- The specific latent heat of vapourization.

**Suggested learning / suggested activities:**

- Carry out simple activities to show the shape and volume taken by solids, liquids and gases.

- Explain the structure of matter by describing the inter-molecular/particle attractive forces.

- Use suitable experiments and draw phase changing curves for fusion and vapourization to show that the temperature remains constant during change of state.

- Discuss that the term ‘latent heat’ is used, because heat is absorbed or emitted while the temperature remains constant.

- Define the terms
  1. The specific latent heat of fusion.
  2. The specific latent heat of vapourization.

- Discuss some examples and carry out activities to show the effect of pressure on boiling point and melting point.

- State that boiling point and melting point changes with pressure.

**Laboratory practical:**

- Conduct a practical to determine specific latent heat of fusion and vapourization.

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

**No of periods : 04**

**Learning outcomes:**

Student will be able to:

- explain the behaviour of unsaturated and saturated water vapour.
- illustrate graphically the variation of saturated vapour pressure and unsaturated vapour pressure with temperature and with volume.
- explain the humidity refers to the moisture (amount of water vapour present) in the atmosphere.
- carry out calculations on relative humidity, absolute humidity and dew point.

**Guidelines:**

- A closed vessel partly filled with a liquid containing molecules of the liquid and molecules of the vapour so that molecules of the vapour can exert a pressure.
- Absolute humidity.
- Relative humidity.
- The factors which tend to vary relative humidity.
- Dew point.
- The process of boiling
- Comparison of boiling (vapourization) and evaporation
- How the boiling point varies with pressure.
- Expressions of relative humidity using mass of vapour, partial pressure of vapour and dew point.

$$\text{relative humidity} = \frac{\text{mass of water vapour in a certain volume}(m)}{\text{mass needed to saturate the same volume at the same temperature}(M)} \times 100\%$$

$$\text{relative humidity} = \frac{\text{partial water vapour pressure}}{\text{saturated water vapour pressure at room temperature}} \times 100\%$$

$$\text{relative humidity} = \frac{\text{water vapour pressure at dew point}}{\text{saturated water vapour pressure at room temperature}} \times 100\%$$

**Suggested leaning / teaching activities:**

- Discuss situations where evaporation occurs.
- Carry out activities to show that temperature decreases when the evaporation occurs.
- Use the molecular kinetic theory to explain evaporation.
- Carry out activities to demonstrate that molecules of vapour exert a pressure. This can be demonstrated using a simple barometer by introducing few drops of ether to the empty space of the barometer.
- Carry out activities to show the difference of unsaturated vapour and saturated vapour.
- Explain the state of dynamic equilibrium set up between the liquid and vapour.
- Explain that the vapour pressure attains the maximum value when the vapour is in the saturated state.
- Carry out activities to show that the unsaturated vapour pressure varies with volume and saturated vapour pressure does not vary with volume and illustrate this graphically.
  The simple barometer can be used for this activity.
- Carry out activity to show the relationship between vapour pressure and temperature.
  This can be done by heating the vapour to various temperatures and measuring the pressure.
- Show graphically, the relationship between saturated and unsaturated vapour pressure and temperature.
- Discuss the relationship between boiling point and saturated vapour pressure.
- Explain that the moisture content of the atmosphere is referred to as humidity.
- Define absolute humidity and relative humidity.
- Explain dew point.

- Give expressions for relative humidity using mass of vapour, partial pressure of vapour and dew point.
- Determine dew point using a polished calorimeter.
- Show by simple experiments the influence of changing pressure on boiling point.
- Explain the exchange of heat associated with vaporization and condensation.
- Explain how heat absorbs when a liquid vapourizes which is used in refrigeration and air conditioning.
- Conduct a discussion to compare the evaporation and boiling.

**Laboratory practical:**

- 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:**

Student will be able to:

- demonstrate and explain the first law of thermodynamics.
- use the first law of thermodynamics to explain the changes of a gas.
- carry out calculations using the first law of thermodynamics.

**Guidelines:**

- The term 'internal energy'
- The first law of thermodynamics.
- Relationship between molar heat capacity of constant volume of a gas to its molar heat capacity at constant pressure.
- Adiabatic and isothermal changes
- Constant pressure and constant volume changes.
- Objects contain internal energy, not heat. Heat is energy on the move due to temperature difference. So we must think of heat in the same way as we think of work.
- Work is, energy transferred by forces when they move.
- Heat is, energy transferred due to temperature difference.
- Internal energy is, the energy contained in an object due to the kinetic energy and potential energy of its molecules.
- $\Delta Q = \Delta U + \Delta W$

  $\Delta Q$ -heat given to the system.
  $\Delta U$ -change in internal energy of the system
  $\Delta W$ -external work done by the system.

- Show that the work done at constant pressure $\Delta W = P\Delta V$ by considering a gas enclosed in a cylinder by means of a smooth piston.

- Explain that for an isothermal process $\Delta U = 0$
  Therefore, $\Delta Q = \Delta W$

- Explain that for an adiabatic process $\Delta Q = 0$
  Therefore, $\Delta W = -\Delta U$ and $-\Delta W = \Delta U$
  Discuss both the situations.

- Explain that for a constant volume process, $\Delta W = 0$
  Therefore, $\Delta Q = \Delta U$

**Suggested learning /teaching activities:**

- Describe that the energy is transferred from a body at a higher temperature to a body at a lower temperature and the heat as a state of transfer of energy.

- Carry out the following activities to develop the first law of thermodynamics

**Stretching a rubber band** provides a simple example of using thermodynamics.

1. Stretch a rubber band quickly then hold it, still stretched, against your lower lip. It feels warm. The internal energy of the rubber increases because you have done work on the rubber band when you stretched it. The stretching was so rapid that heat transfer was negligible. An energy transfer where no heat transfer occurs is called an adiabatic change.
2. Keep the rubber band stretched against your lip and you should find that it cools to 'lip' temperature. Its internal energy falls due to heat transfer to the surroundings. No work is done because there is no movement.
3. Now release the rubber band quickly, and put it unstretched against your lip again. You ought to find that it becomes colder than 'lip' temperature as a result of unstretching. Its internal energy has fallen because internal forces in the rubber do work as it unstretches. No heat transfer occurs because the change is rapid.
4. Finally the unstretched rubber warms up to 'lip' temperature because heat transfer from the room increases its internal energy.

**Compressing a gas** provides another example. *Figure 4.1* shows a simple arrangement of a bicycle pump with a blocked outlet. A thermocouple inserted through the blocked outlet allows the air temperature inside the pump to be monitored.

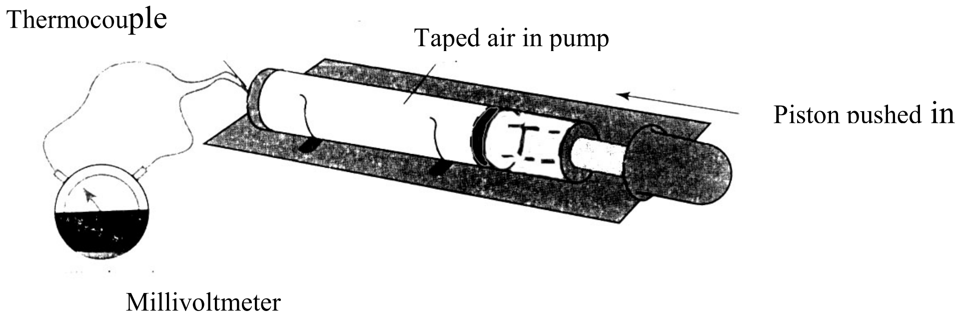



*Figure 4.1 Compressing a gas.*

1. Push the piston in rapidly and hold it in position. The thermocouple thermometer ought to show a temperature rise due to increase of internal energy of the air. The pushes force dose work on the air rapidly, so no heat transfer from the air occurs. Hence the work done increases the internal energy.
2. Return the piston to its initial position and allow the temperature to return to its initial value as well. Then push the piston in very gradually. No temperature rise occurs this time. Why? You still do work on the air as you push the piston in. However, any slight rise of temperature causes heat transfer from the air so the temperature returns to the initial value. In other words, heat transfer from the air occurs at the same rate as work is done on it. So no rise of internal energy occurs.

- Explain that when a process is carried out slowly, the system has time to exchange heat with the surrounding and therefore the temperature remains constant.

- Describe the change in temperature with pressure of a gaseous system in an adiabatic process using suitable activities (gas unit kit).

- Develop the idea by discussion that the temperature changes during an instantaneous process as no heat transference takes place with the surrounding.

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

**No of periods:** 04

**Learning outcomes:**

Student will be able to:

- describe heat transfer mechanics indicating conduction, convection and radiation.
- measure and calculate thermal conduction.

**Guidelines:**

- The processes of transference of heat
- The mechanisms of these processes with examples
- The factors, which determine the amount of heat, conducted through a rod
- The thermal conductivity
- The equation $\frac{dQ}{dt} = kA\frac{(\theta_1 - \theta_2)}{l}$ for rate of heat flow through an insulated rod.
- The differences between natural convection and forced convection

**Suggested learning/teaching activities:**

- Carry out activities such as, heating a metal rod coated with wax, a flask of water containing few crystals of Potassium Permanganate ($KMnO_4$).
- Conduct the activity using rods of various lengths and cross sections and use the results to explain the nature of heat conduction.
- Discuss the factors, which determine the amount of heat conducted through a rod.
- Define thermal conductivity.
- Describe the natural convection giving examples.
- Discuss convection.
- Discuss radiation.

**Laboratory practical:**

- Determination of thermal conductivity using Searle's method.

# SCHOOL BASED ASSESEMENT

# Introduction- School Based Assessment

Learning –Teaching and Evaluation are three major components of the process of Education. It is a fact that teachers should know that evaluation is used to assess the progress of learning –teaching process. Moreover, teachers should know that these components influence mutually and develop each other .According to formative assessment (continuous assessment) fundamentals; it should be done while teaching or it is an ongoing process. Formative assessment can be done at the beginning, in the middle, at the end and at any instance of the learning teaching process.

Teachers who expect to assess the progress of learning of the students should use an organized plan. School based assessment (SBA) process is not a mere examination method or a testing method. This programme is known as the method of intervening to develop learning in students and teaching of teachers. Furthermore, this process can be used to maximize the student's capacities by identifying their strengths and weaknesses closely.

When implementing SBA programmes, students are directed to exploratory process through Learning Teaching activities and it is expected that teachers should be with the students facilitating, directing and observing the task they are engaged in.

At this juncture students should be assessed continuously and the teacher should confirm whether the skills of the students get developed up to expected level by assessing continuously. Learning teaching process should not only provide proper experiences to the students but also check whether the students have acquired them properly. For this, to happen proper guiding should be given.

Teachers who are engaged in evaluation (assessment) would be able to supply guidance in two ways. They are commonly known as feed-back and feed- forward. Teacher's role should be providing Feedback to avoid learning difficulties when the students' weaknesses and inabilities are revealed and provide feed-forward when the abilities and the strengths are identified, to develop such strong skills of the students.

Student should be able to identify what objectives have achieved to which level, leads to Success of the Learning Teaching process. Teachers are expected to judge the competency levels students have reached through evaluation and they should communicate information about student progress to parents and other relevant sectors. The best method that can be used to assess is the SBA that provides the opportunity to assess student continuously.

Teachers who have got the above objective in mind will use effective learning, Teaching, evaluation methods to make the Teaching process and learning process effective. Following are the types of evaluation tools student and, teachers can use. These types were introduced to teachers by the Department of Examination and National Institute of Education with the new reforms. Therefore, we expect that the teachers in the system know about them well

Types of assessment tools:

| | |
|---|---|
| 1. Assignments | 2. Projects |
| 3. Survey | 4. Exploration |
| 5. Observation | 6. Exhibitions |
| 7. Field trips | 8. Short written |
| 9. Structured essays | 10. Open book test |
| 11. Creative activities | 12. Listening Tests |
| 13. Practical work | 14. Speech |
| 15. Self creation | 16. Group work |
| 17. Concept maps | 18. Double entry journal |
| 19. Wall papers | 20. Quizzes |
| 21. Question and answer book | 22. Debates |
| 23. Panel discussions | 24. Seminars |
| 25. Impromptus speeches | 26. Role-plays |

Teachers are not expected to use above mentioned activities for all the units and for all the subjects. Teachers should be able to pick and choose the suitable type for the relevant units and for the relevant subjects to assess the progress of the students appropriately. The types of assessment tools are mentioned in Teacher's Instructional Manuals.

If the teachers try to avoid administering the relevant assessment tools in their classes there will be lapses in exhibiting the growth of academic abilities, affective factors and psycho-motor skills in the students

# Term 1

**Evaluation Plan No. 1**

| | | | |
|---|---|---|---|
| 1.0 | Evaluation | : | Term 1 – Instrument -1 |
| 2.0 | Competency Level Covered | : | 1.1, 1.2, and 1.3. |
| 3.0 | Subject content covered | : | Relevant content in competency levels |
| 4.0 | Nature of Instrument | : | Presentation of literature review |
| 5.0 | Objectives | | 1. To develop skills of exploration<br>2. To make a good foundation in students to learn physics<br>3. To identify mathematical and experimental background of physics<br>4. To develop presentation skills |

**Evaluation Plan No. 2**

| | | | |
|---|---|---|---|
| 1.0 | Evaluation | : | Term 1 – Instrument -2 |
| 2.0 | Competency Level Covered | : | 1.4 |
| 3.0 | Subject content covered | : | Relevant content in competency level |
| 4.0 | Nature of Instrument | : | Practical test |
| 5.0 | Objectives | | 1. To develop skills in handling apparatus<br>2. To make understanding of the importance of measurement<br>3. To improve social skill |

**Evaluation Plan No. 3**

| | | | |
|---|---|---|---|
| 1.0 | Evaluation | : | Term 1 – Instrument -3 |
| 2.0 | Competency Level Covered | : | 1.6 |
| 3.0 | Subject content covered | : | Relevant content in competency level |
| 4.0 | Nature of Instrument | : | Portfolios |
| 5.0 | Objectives | | 1. To use graphs to represent data<br>2. To improve the skills of using graphs and analyze the nature of variable in an experiment<br>3. To improve the presentation skills |

**Evaluation Plan No. 4**

| | | | |
|---|---|---|---|
| 1.0 | Evaluation | : | Term 1 – Instrument -4 |
| 2.0 | Competency Level Covered | : | 2.1 |
| 3.0 | Subject content covered | : | Relevant content in competency level |
| 4.0 | Nature of Instrument | : | Question and answer book |
| 5.0 | Objectives | | 1. To use questions of motion<br>2. To use graphs of motion<br>3. To develop mathematical skills |

**Evaluation Plan No. 5**

| | | | |
|---|---|---|---|
| 1.0 | Evaluation | : | Term 1 – Instrument -5 |
| 2.0 | Competency Level Covered | : | 2.2, 2.3, 2.4 and 2.5 |
| 3.0 | Subject content covered | : | Relevant content in competency levels |
| 4.0 | Nature of Instrument | : | Question and answer book |
| 5.0 | Objectives | | 1. To identify law and theories related to motion<br>2. To identify where those laws and theories are applied in real world<br>3. To develop mathematical skills |

## Term 2

**Evaluation Plan No. 1**

| | | | |
|---|---|---|---|
| 1.0 | Evaluation | : | Term 2 – Instrument -1 |
| 2.0 | Competency Level Covered | : | 2.6, 2.7, and 2.8 |
| 3.0 | Subject content covered | : | Relevant content in competency levels |
| 4.0 | Nature of Instrument | : | Presentation of literature review |
| 5.0 | Objectives | | 1. To understand the most useful forms of alternative energy resources<br>2. To identify the principles and laws of hydrostatics and fluid dynamics<br>3. To improve the presentation skills |

**Evaluation Plan No. 2**

| | | | |
|---|---|---|---|
| 1.0 | Evaluation | : | Term 2 – Instrument -2 |
| 2.0 | Competency Level Covered | : | 3.1 |
| 3.0 | Subject content covered | : | Relevant content in competency level |
| 4.0 | Nature of Instrument | : | Concept map |
| 5.0 | Objectives | | 1. To identify terms related to oscillation<br>2. To relate the physical quantities of simple harmonic motion<br>3. To improve the conceptual understanding on oscillation |

**Evaluation Plan No. 3**

| | | | |
|---|---|---|---|
| 1.0 | Evaluation | : | Term 2 – Instrument -3 |
| 2.0 | Competency Level Covered | : | 3.2 and 3.3 |
| 3.0 | Subject content covered | : | Relevant content in competency levels |
| 4.0 | Nature of Instrument | : | Questions and answer book |
| 5.0 | Objectives | | 1. To familiarize the equations<br>2. To understand the nature of a wave<br>3. To apply the knowledge of waves to explain real world situations |

**Evaluation Plan No. 4**

| | | | |
|---|---|---|---|
| 1.0 | Evaluation | : | Term 2 – Instrument -4 |
| 2.0 | Competency Level Covered | : | 3.4. |
| 3.0 | Subject content covered | : | Relevant content in competency level |
| 4.0 | Nature of Instrument | : | Practical test |
| 5.0 | Objectives | | 1. To improve the skills of taking measurements<br>2. To improve the skills of designing of experiments |

**Evaluation Plan No. 5**

| | | | |
|---|---|---|---|
| 1.0 | Evaluation | : | Term 2 – Instrument -5 |
| 2.0 | Competency Level Covered | : | 3.5. |
| 3.0 | Subject content covered | : | Relevant content in competency level |
| 4.0 | Nature of Instrument | : | Practical test |
| 5.0 | Objectives | | 1. To demonstrates the occurrence of resonance<br>2. To improve the skills of handling apparatus<br>3. To improve the skills of graphical representation |

## Term 3

**Evaluation Plan No. 1**

| | | | |
|---|---|---|---|
| 1.0 | Evaluation | : | Term 3 – Instrument -1 |
| 2.0 | Competency Level Covered | : | 3.6, 3.7, and 3.8 |
| 3.0 | Subject content covered | : | Relevant content in competency levels |
| 4.0 | Nature of Instrument | : | Panel discussion |
| 5.0 | Objectives | | 1. To motivate students to investigate the application of Doppler effect<br>2. To develop the understanding of sounds<br>3. To list out characteristics of the various parts of the electromagnetic spectrum<br>4. To improve the social skills |

**Evaluation Plan No. 2**

| | | | |
|---|---|---|---|
| 1.0 | Evaluation | : | Term 3 – Instrument -2 |
| 2.0 | Competency Level Covered | : | 4.1 and 4.2 |
| 3.0 | Subject content covered | : | Relevant content in competency levels |
| 4.0 | Nature of Instrument | : | Panel discussion |
| 5.0 | Objectives | | 1. To investigate on temperature and measuring of temperature<br>2. To investigate applications of thermal expansion<br>3. To improve the social skills |

**Evaluation Plan No. 3**

| | | | |
|---|---|---|---|
| 1.0 | Evaluation | : | Term 3 – Instrument -3 |
| 2.0 | Competency Level Covered | : | 4.3 and 4.4 |
| 3.0 | Subject content covered | : | Relevant content in competency levels |
| 4.0 | Nature of Instrument | : | Concept map |
| 5.0 | Objectives | | 1. To identify the behaviour of gases<br>2. To relate physical quantities of gases<br>3. To improve the social skills |

**Evaluation Plan No. 4**

| | | | |
|---|---|---|---|
| 1.0 | Evaluation | : | Term 3 – Instrument -4 |
| 2.0 | Competency Level Covered | : | 3.9 |
| 3.0 | Subject content covered | : | Relevant content in competency level |
| 4.0 | Nature of Instrument | : | Practical test |
| 5.0 | Objectives | | 1. To improve practical skills<br>2. To develop the understanding of light<br>3. To improve the social skills |

**Evaluation Plan No. 5**

| | | | |
|---|---|---|---|
| 1.0 | Evaluation | : | Term 3 – Instrument -5 |
| 2.0 | Competency Level Covered | : | 3.10, 3.11, 4.5, and 4.6 |
| 3.0 | Subject content covered | : | Relevant content in competency levels |
| 4.0 | Nature of Instrument | : | Question and answer bank |
| 5.0 | Objectives | | 1. To improve of mathematical skills<br>2. To understand the behavior of matter on heat<br>3. To apply knowledge of refraction to investigate the action of human eye and optical instruments. |

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