Centre for Distance & Online Education

UNIVERSITY OF JAMMU
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B.Ed.
SEMESTER-III

PAPER : Teaching of Physical Science **UNIT : I-IV**
Course No. : 302 **Lesson No. : 1-12**

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TEACHING OF PHYSICAL SCIENCE

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BACHELOR OF EDUCATION (B.Ed.)

SEMESTER-III

(For the examination to be held in the year 2018, 2019 and 2020)

Methodology of Teaching Subject-II

Course No. 302 (Theory) **Title : Teaching of Physical Science**

Credits : 4 **Total Marks : 100**

Maximum Marks Internal : 40

Maximum Marks External : 60

Duration of Examination : 3 hrs.

Objectives :

To enable the pupil teachers to :

- Develop a broad understanding of physical science.
- Develop teaching competencies related to physical science at secondary level.
- Become effective teachers in order to perform desired role of a physical science teacher.
- Familiarize themselves with the type of audio visual aids, techniques and methods of teaching required for teaching of physical science.
- Evaluate students performance and provide remedial teaching.

UNIT - I

Concept of physical science: Physical science and society (Physical science for health and physical science for environment). Contribution of some eminent scientists (Issac Newton, John Dalton, Eienstein, Bohr and C.V. Raman). Role of school. Professional qualities and professional growth of a physical science teacher.

UNIT - II

Audio-Visual Aids: Meaning, importance, types and use of audio- visual aids for teaching of physical science. Role and organization of the following in teaching of physical science - field trips, science clubs, science museum, science fairs, physical science lab and preparation of low cost teaching aids in teaching of physical science. Techniques of teaching : Lecture-cum-demonstration method, project method, problem solving method, inductive deductive method and heuristic method.

UNIT - III

Evaluation : Meaning and purpose of evaluation.

Types of Evaluation - Formative and summative evaluation.

Evaluation tools - Diagnostic testing and remedial teaching, oral tests, quizzes, essay type tests and objective type tests.

UNIT - IV

Reflection : Reflection of light at curved surfaces, images formed by spherical mirrors. Refraction : Laws of refraction, refractive index, refraction of light through a prism, dispersion and scattering of light. Metals and non-metals : Physical and chemical properties, difference between metals and non-metals, corrosion and prevention of corrosion.

Sessional work

Report on a visit to area of natural calamity/science museum/science fair.

Note for Paper Setters :

The Question paper consists of 9 questions having Q. No. 1 as compulsory having four parts spread over the entire Syllabus, with a weightage of 12 marks. The rest of Question paper is divided into four Units and the students are to attempt four Questions from these units with the internal choice. The essay type Question carries 12 marks each. Unit IV having the sessional work/field work (section) could also be a part of the theory paper.

Internship/field work Unit IV having the components/activities of the internship are to be developed in the form of the Reflective Journal. All the activities under internship are to be evaluated for credits and hence all the activities are to be showcased by the trainee and are to be fully recorded with the complete certification of its genuineness.

The theory paper is to have 60 marks (external). 40 marks are for the In- House activities.

References:

- Gupta, S.D. & Sharma, D.R. (2002). *Teaching of Science,* Malhotra Brothers, Jammu.
- Kohli, V.K. (2001). *How to teach science.* Vivek Publishers, Ambala City.
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CONTENTS

Lesson No. : 1 **Unit : I**

CONCEPT OF PHYSICAL SCIENCE

Structure

1.1 INTRODUCTION

One of the important aim of education is to help students to become responsible democratic citizens of the country. The responsibility of science teachers is not only to

teach facts, principles and processes of science, but also to facilitate students to discharge their social responsibilities and preserve democracy as well. They should appreciate how science and technology have developed and are affected by many diverse individuals, cultures and societies. They need to be encouraged to appreciate and participate in the responsible use of science and technology for the benefit of society, to visualize future of our nation and to become sensitive and responsible citizens. It is important to develop critical thinking in them about interconnectivity of science, technology and society in order to maintain a healthy and sustainable society. Students should be encouraged to develop a scientific vision about different issues, about acquiring and processing information, about scientific and technological developments and their relevance to everyday life and long-term implications to society. Therefore, science teachers should view their obligations in a broader perspective.

Science education aims to make students develop scientific attitude, so that in later life they can help society make rational choices when confronted with various possibilities and challenges.For example, a society wishes to argument its energy resources, thereare many possible ways in which energy can be generated. The societywishes to opt for a method which is least harmful ecologically. If thelevel of science literacy is high in the society then its citizens are in abetter position to make correct choice.

1.2 OBJECTIVES

After going through this lesson, you shall be able to-

- explain the meaning of science and physical science,
- establish the relation between physical science and society,
- establish the relation between physical science and health, and
- describe the role of physical science teacher

1.3 WHAT IS SCIENCE

Science as a discipline has its unique perspective. Science is not limited to observation, experimentation and analysis only; rather it is a way of life. Science is an expanding body of knowledge through process of inquiry.

Science is defined in several ways by different individuals. According to Fitzpatrick" science is a cumulative and endless series of empirical observations which result in the formation of concepts and theories, with both concepts and theories being subject to modification in the light of further empirical observations.

Etymologically word 'Science' has been derived from the Latin word 'scientia' which means 'knowing'. Before the 18th century, Science was referred as 'natural philosophy'. Still for some, it is a title; for some, it is a concept, few perceive it as a method or process while for some, it is inquiry. If we go through philosophical origin and understanding of term 'Science', we can see various perceptions about Science and this makes it more interesting and challenging. Similarly, when you look back towards your own childhood and school days, you can find, what was your own perception about Science.

Science is a process of learning. It is very different from other areas of study because "the way to learn Science is to do Science". You can propose it as subject, which always tests ideas with the help of evidences collected from the worlds around us.

Some of the important characteristics of Science are:

- You can help learners to understand that Science does not explain supernatural myths rather it focuses on the natural world around them. For example, Science helps to understand growth in plants, characteristics of animals, etc.
- Learners should understand that Science is not merely a collection of evidences of happenings; rather it attempts to understand happening through analysis, testing and verification.
- You can give examples of Scientists working in different areas and ask learners to find out what is common in their working. Learners will soon realize that scientists work on testing of ideas, that are generated and their verification with the help of evidences generated or collected.

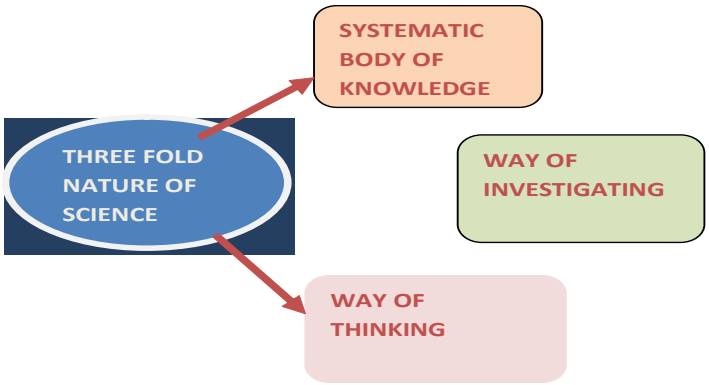
Science is actually an integral part of our daily life. As a teacher you can help learners to understand that scientists are as human as we. They also have feelings of joy, rivalry, competition, success, failure, etc. as any human being.

Being a Science teacher at secondary level, you should ensure that learners should overcome the traditional stereotype/mental blocks related to Science like Science text books are carrying of burden in bags, scientists are persons wearing lab coats and working on microscopes, a natural scientist works in the rainforest, or busy in writing some equations and formula on a chalkboard…. all such images are the reflection of one aspect of Science, but do not offer a full picture…

It is always a debate that what is Science and what it is not. As a Science teacher, we must think on certain issues like why there is no suffix 'Science' with subjects like Physics, Chemistry, Biology, Zoology, Botany, etc., and why there is always a suffix 'Science' with subjects like Social Science, Political Science, Management Science, Environmental Science, Health Science, Library Science, etc.

NATURE OF SCIENCE

Science has Three-Fold nature which are:



- Is a systematic body of knowledge
- Is a way of investigating
- Is a way of thinking

√ **Science as systematic body of knowledge**

This body of knowledge include facts, concepts and theories that are subject to

error and change. Science is dynamic in nature and the scientific information is constantly being rearranged and reoriented, in the light of new knowledge.

√ **Science as way of investigating**

Science teachers should emphasize that scientists approach the solution of nay specific problem in an organized manner with inspiration, imagination and insight.

√ **Science as way of investigating**

The acquisition of scientific attitudeis one of the most important outcomes of science. A person with a scientific attitude will have the following characteristics:

1. Open mindedness
2. Objectivity
3. Freedom from superstitious
4. Belief in cause- effect relationship
5. Accuracy and truthfulness in reporting observations
6. Methodical way of solving a problem
7. Up-to-datedness.

Aspects of Nature of Science:

1. Scientific knowledge is long lasting yet tentative
2. Empirical evidence is used to refine and support ideas in Science
3. Social and historical factors play a role in the construction of scientific knowledge
4. Laws and theories play a central role in developing scientific knowledge, yet they have different functions
5. Accurate record keeping, peer review, and replication of experiments help to validate scientific ideas
6. Science is a creative endeavor
7. Science and Technology are not the same, but they have impact on each other.

1.5 PHYSICAL SCIENCE

As physical science deals with the matter and energy so physical science is made up with the combination of physics and chemistry. It is one of the most fundamental science. It helps us to understand the other sciences such as chemistry, geology, biology. Medical sciences and other host sciences.

1.6 PHYSICAL SCIENCE AND SOCIETY

"We live in a society … dependent on science and technology, in which hardly anyone knows anything about science and technology." **(Carl Sagan)**

Science has developed for facilitating society in explaining various **natural phenomena**. In our own Indian literature, there are examples from Rigveda, where it has been explained that how Earth rotates around Sun in 12 months. There are slokas and verses in Kalpsutra which have explained many relationships of squares, triangles, circles, even many years before Pythagoras. How Ayurveda and Surgery were being used to help society in being healthy, there are books on it. In modern Science, haveyou read a famous book 'A brief History of Time' by Stephen Hawking, or can you imagine the impact of 'Origin of Species' written by Charles Darwin? These are few examples to initiate the discussion on relationship of Science and society.

There are so many examples that shows us the connection between the physics, technology and society.

The principle of lever has been utilized for thousands of years in the development of civilization. The ancient Egyptians used levers to lift obelisks (tall, pointed, tapering, four-sided stone pillar, set up as a monument or landmark) weighing in excess of 100 tons.

The discipline of thermodynamics (the branch of physical science that deals with the relations between heat and other forms of energy (such as mechanical, electrical, or chemical energy), and, by extension, of the relationships between all forms of energy.)arouse from the need, to understand and improve the working of heat engines. Invention of the steam engine initiated the industrial revolution in England in the eighteenth century, which had great impact on the course of human civilization.

Sometimes technology generates new physics; at other times physics generates new

technology. An example of this is the wireless communication technology that followed the discovery of the basic laws of electricity and magnetism in the nineteenth century. The most significant area to which physics can contribute is the development of alternative energy resources. If nuclear fusion experiment is controlled to generate energy, it can bring prosperity in our society. Chemistry is the study of properties and uses of matter. It is also one of the basic sciences and serves as foundation to understanding of biochemistry, molecular genetics, physics, geology, physiology, etc. Many new chemicals developed by chemists have important significance to society. To name a few, the book you are reading, the clothes you are wearing, the ink in your pen, materials for computers and mobiles, the lifesaving medicines are all developed by the chemists.

Nylon was developed as a synthetic material in 1931 without using any natural raw material derived from plant or animal. It was prepared from coal, water and air. This fiber is strong, elastic and light. Since it was lustrous and easy to wash, it became very popular for clothes. Due to this, a number of scientific and technological advancements took place. Agricultural chemicals like herbicides, fungicides, hemic acid (to increase availability of plant nutrients), Indole acetic acid (a plant hormone that prevents fruits from dropping prematurely) and calcium sulphate (to reduce soil acidity) play important roles in the way we cultivate crops.

`Identification of specific fuel additives and suitable vehicular material has made transportation efficient and comfortable. Similarly, electronics and computer technology have become advanced because of a variety of chemicals having specific properties. However, the advantages of these scientific developments have not been unalloyed. Many new developments have adverse effects on our environment. The study of these effects and the need to minimize damage to the environment gave rise to a new branch of science — **environmental science**. Thus, we find that the interaction between science and society is never unidirectional.

The following values can be developed through teaching-learning of science:

- **Patience:** In waiting for results of experiments.

- **Perseverance:** In doing the experiments again and again until result is achieved.
- **Cooperation:** Willingness to work with others, and share equipment's and materials.
- **Honesty:** In gathering and recording data.
- **Integrity:** Whose work can be relied upon.
- **Concern for life:** Caring for health and hygiene and others.
- **Preservation of environment:** Keeping surroundings clean, caring for plants and animals, switching off the light when not in use.

1.6.1 Physical Science for Environment

Environment means our surroundings and everything that is present around us. It includes air, water, soil, the sun, the moon and other things i.e. plants, animals, rivers, mountains, deserts and oceans. Our environment has four segments— atmosphere, biosphere, lithosphere and hydrosphere. In science we deal with facts, concepts and principles that take place in nature. For a long time, human beings remained part of natural system and were not able to tinker with it. Then they started making tools, invented fire, do agricultural work and domesticated animals. At this stage, humans were depended so much on agriculture that they could be called **agricultural beings**. Later they started using nature and its resources according to their own demands. These developments transformed human into **industrial beings**.

At the present time, the volume of knowledge is growing at such a tremendous rate that it will not be an exaggeration that we have transformed ourselves into **knowledge beings**. By their activities, humans brought about changes in the environment. These activities have resulted in pollution of the environment. Of late, pollution has started increasing at an alarming rate. This has drawn attention of the general public as well as of the scientists. The study of the effects of contaminants (physical, chemical, biological) on the environment has also become part of science.

Scientists started working on the prevention of pollution of water, air, soil, noise, and that caused by radioactivity. For example, the use of Compressed natural gas (CNG)

as fuel in preference to petroleum and diesel, helps in reducing the level of carbon dioxide in the air. Also, alternative sources of energy such as wind, solar, nuclear, biogas, tides, geothermal, etc. have been explored and their use is growing. These measures would surely decrease pollution and the global warming. Ozone depletion has been checked largely by aerosols, such as Chloroform carbons (CFCs), so that they do not accumulate in the atmosphere. Suitable devices have been installed at the sites to map the noise pollution and to control it. Various measures have been employed for controlling the radioactive pollution. Thus, science is essential for the study of the environment and its improvement.

Check Your Progress-1

Note: (a) Answers the question given below.

(b) Compare your answers with those given at the end of the lesson.

1. In science we learn about the environmental phenomena of both_____ and _____ interventions affecting the environment.
2. The study of the effects of contaminants (physical, chemical, biological) on the environment has also become part of _____
3. Sometimes_____ generates new physics; at other times_____generates new technology.
4. Which principle has been utilized for thousands of years in the development of civilization?
5. Science is static in nature. (true / false)
6. Physical science is one of the most fundamental science. (true/ false)
7. Which thinking should develop in students in order to maintain a healthy and sustainable society?
8. Name any two characteristics that shows the scientific attitude of the students.

1.6.1.1 Relating Science Education with the Environment

The major and the prime concern of the educationists is to relate education with the

environment of children. The environment of a child includes natural and social environment, artifacts and people.

In science we learn about the environmental phenomena of both natural and man-made interventions that affect the environment. Science education is mainly of the environment and for the environment. Therefore, every effort should be made to integrate science with learning the environment.

The science curriculum should address issues and concerns related to environment such as climate change, acid rain, growth of water eutrophication and various types of pollution, etc. through teaching-learning of science at all stages. Students will be attracted towards science when they realise its significance to society and relevance to their lives. Science teacher should aim to enlighten the young minds with the wonders of science.

Students should be made to realise the significance of discoveries, inventions and principles of physical science through their everyday experiences. They should be engaged to construct the knowledge of physical science through an interdisciplinary approach appreciating its relation and impact on the social and natural environment.

They can recognise the importance of science/physics/chemistry by doing activities related to their everyday life. Current issues and events in science like new technological innovations, scientific discoveries, industrial accidents can be examined through social, economic and ethical perspectives to help students in relating these issues with one another and explore their areas of interests.

1.6.2 Physical Science for Health

The one important indication that shows the progress of a society is there healthy members.

The disease and poverty form a vicious circle. People are poor, because they are suffering from various diseases; people are suffering from various diseases, because they are poor. Therefore, for poverty alleviation, it is essential that people should be healthy.

Science has served humankinds to a great extent for making its members healthy

and free from diseases. It has formalized the consumption of various nutrients such as proteins, carbohydrates, vitamins, fats, minerals, etc. in requisite amounts for a person to remain healthy. Science has found out some remedial measures so that people do not die due to diseases like malaria, tuberculosis and hepatitis B. Various diagnostic techniques have also been developed, e.g., MRI, ECG, X-rays, ultrasonography, etc.

Use of antibiotic medicines has freed humankind from several dangerous diseases such as syphilis, tuberculosis, leprosy. Recently a number of drugs have been developed for chemotherapeutic treatment of cancer. Radiotherapy has proved to be a potential therapy for removing tumor.

The scientists from various countries have contributed in this area. India's contribution to health sciences is quite important Physical science has contributed a lot in reducing human suffering by the discovery of anesthesia and antisepsis to be used for surgery and various medicines such as painkillers, antibiotics, sedatives, etc. to relieve pain and sufferings.

One of the humming issues facing the society today is to provide health care to all its members. Scientific vision of health care an understanding the intricacies of modern medicines can enable the society to choose the right path to follow.

1.6.2.1 Role of a Teacher

Controller of activities: science teacher is the controller of activities released to science. He/ she will be the only person who supervises all the activities.

Represent society: science teacher acts as a connection between students and society. He has the duty to take the students to society and develops them in such

Formulation of curriculum: The teacher has to frame the curriculum for their students. He has to select the subject matter for curriculum, arrange the contents and relate it to daily life of the students.

Teaching aid preparation: The teacher has to prepare teaching aids according to needs, abilities interests and learning styles of the students. These teaching aids help the students to learn science and effectively.

Formulation of textbook: science teacher has to prepare textbooks according to

the student's requirements; the textbooks should be true representation of syllabus of science.

Student's Evaluation: The teacher has to measure each and every aspect of student's ability. In real words, he has to evaluate the students.

Check Your Progress-2

Note: (a) Answers the question given below.

(b) Compare your answers with those given at the end of the lesson.

1. Teacher must develop _____and_____ relationship with students and colleague
2. _____climate of the school and classroom has a deep influence on the learning process of the learners.
3. Science teacher acts as a connection between students and _____.
4. The teacher has to prepare teaching aids according to needs, _____. _____and learning styles of the students.
5. Use of _____has freed humankind from several dangerous diseases such as syphilis, tuberculosis, leprosy.
6. One of the humming issues facing the society today is to provide_____to all its members.
7. The environment of a child includes _____and _____environment, artifacts and people.
8. Science has found out some _____ so that people do not die due to diseases like malaria, tuberculosis and hepatitis B.

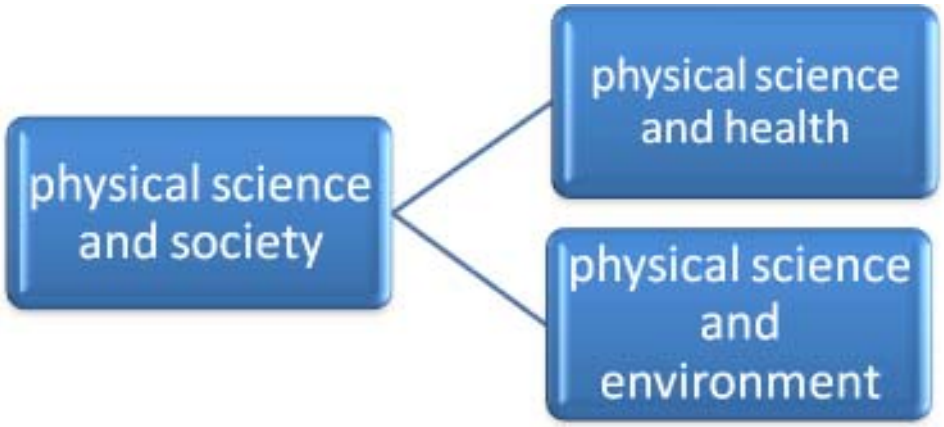
1.7 LET US SUM UP

- **Physical science**

Physical science is basically the study of Physics and Chemistry. It one of the most fundamental sciences so it deals with the study of matter and energy.

- **Physical science and society**

  Physical science has a relation with the society as there are so many properties of physical sciences that are used in daily life to deal in the society.



- **Role of teacher**

  The role of science teacher is to make connection between the students and the society.

1.8 LESSON END EXERCISE

1. Name the four segments of the environment.
2. Describe the role of a science teacher.
3. What there is need for the student to relate physical science with health

1.9 SUGGESTED READINGS AND REFERENCES

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1.10 ANSWERS TO CHECK YOUR PROGRESS

Answer to Check Your Progress -1

1. natural and man-made
2. science.
3. technology, physics
4. principle of lever
5. false
6. true
7. critical thinking
8. objectivity, up-to-datedness.

Answer to Check Your Progress- 2

1. warm, supportive.
2. Social
3. society.
4. abilities and interests.
5. antibiotic medicines.
6. Health care.
7. Natural and social.
8. Remedial Measures.

Lesson No. : 2 **Unit : I**

CONTRIBUTION OF SOME EMINENT SCIENTISTS

Structure

2.1 INTRODUCTION

Students should appreciate how science and technology have developed and is affected by many diverse individuals, cultures and societies. All scientific developments are due to the contributions of great minds in the field of science.

Societies at large have benefited due to their contribution. Let us now see contribution of some eminent scientist

2.2 OBJECTIVES

After going through this lesson, you shall be able to:

- define physical science,
- explain the contribution of Indian scientists in physical sciences, and
- describe the contribution of British scientists in physical sciences.

2.3 PHYSICAL SCIENCE

Physical science includes study of Physics and Chemistry. Physics is one of the most fundamental sciences. It deals with the study of matter and energy. Study of physics helps us to understand other sciences such as chemistry, biology, geology, astronomy, medical science, environmental science, and host of other sciences.

Physical science emerged in western countries by the combined effect of the weakening of the influence of Christian religion and the growing importance of sensory experiences in the context of studying nature. The general feature of science is to study the regularities in nature, which are commonly referred to as natural laws. It did not happen in India.

Basic Principles of Physical Science

- The aim of physics is to study the properties and cause-effect relations of physical world, viewed as a machine following determinate laws. Spiritual beings like God and Soul are outside the scope of physical science.
- As per the knowledge of our scientific mind, we can treat that the physical world is real and it is made of minute particles of matter called atoms.
- All atoms consist of homogeneous substance and it is denoted by the word matter. The essential property of matter is extension or mass.
- Energy is required for the motion of atoms and higher order substances. But the original source of energy is unknown to science. Newton believed that gravitational force is the basic form of energy and it is derived from God. Matter and energy are independent entities of physical world. The notion of space is intimately linked to matter while time is related to energy. In this situation space and time are absolute and independent entities.
- The material structure formed by matter and energy is generally called as body. Accordingly, physical laws are the cause-effect relations between particular bodies expressed in measurable quantities.

2.4 CONTRIBUTION OF SOME EMINENT SCIENTISTS

2.4.1 Isaac Newton 1642-1727 (85 years)

Sir Isaac Newton is generally regarded as the most original and influential theorist in the history of science. His passion was to unite knowledge and belief, to reconcile the Book of Nature with the Book of Scripture. He transformed the structure of physical science with his three laws of motion and the law of universal gravitation, which he used to precisely predict the motions of stars, and the planets around the sun. Without Newton and his discoveries, our modern world would be far different than it is today.

Isaac Newton's Scientific Achievements and Discoveries:

Achievements in Brief

Isaac Newton, who was largely self-taught in mathematics and physics:

- generalized the binomial theorem
- showed that sunlight is made up of all of the colours of the rainbow. He used one glass prism to split a beam of sunlight into its separate colours, then another prism to recombine the rainbow colours to make a beam of white light again.
- built the world's first working reflecting telescope.
- discovered/invented calculus, the mathematics of change, without which we could not understand the behaviour of objects as tiny as electrons or as large as galaxies.
- wrote the *Principia*, one of the most important scientific books ever written; in it he used mathematics to explain gravity and motion. (*Principia* is pronounced with a hard c.)
- discovered the law of universal gravitation, proving that the force holding the moon in orbit around the earth is the same force that causes an apple to fall from a tree.
- formulated his three laws of motion – *Newton's Laws* – which lie at the heart of the science of movement.
- showed that Kepler's laws of planetary motion are special cases of Newton's universal gravitation.
- proved that all objects moving through space under the influence of gravity must follow a path shaped in the form of one of the conic sections, such as a circle, an ellipse, or a parabola, hence explaining the paths all planets and comets follow.
- showed that the tides are caused by gravitational interactions between the earth, the moon, and the sun.
- predicted, correctly, that the earth is not perfectly spherical but is squashed into an oblate spheroid, larger around the equator than around the poles.
- Used mathematics to model the movement of fluids – from which the concept of a *Newtonian fluid* comes.

- devised *Newton's Method* for finding the roots of mathematical functions.

Some Details about Newton's Greatest Discoveries:

Calculus

Newton was the first person to fully develop calculus. Calculus is the mathematics of change. Modern physics and physical chemistry would be impossible without it. Other academic disciplines such as biology and economics also rely heavily on calculus for analysis.

In his development of calculus Newton was influenced by **PIERRE DE FERMET**, who had shown specific examples in which calculus-like methods could be used. Newton was able to build on Fermat's work and generalize calculus. From Newton's fertile mind came the ideas that we now call differential calculus, integral calculus, and differential equations. Soon after Newton generalized calculus, Gottfried Leibniz achieved the same result. Today, most mathematicians give equal credit to Newton and Leibniz for calculus's discovery.

Universal Gravitation and the Apple

Newton's famous apple, which he saw falling from a tree in the garden of his family home in Wools Thorpe-by-Colsterworth, is not a myth. He told people that seeing the apple's fall made him wonder why it fell in a straight line towards the centre of our planet rather than moving upwards or sideways.

Ultimately, he realized and proved that the force behind the apple's fall also causes the moon to orbit the earth; and comets, the earth and other planets to orbit the sun. The force is felt throughout the universe, so Newton called it *Universal Gravitation*. In a nutshell, it says that mass attracts mass.

Newton discovered the equation that allows us to calculate the force of gravity between two objects.

Newton's equation: $$F = \frac{G m_1 m_2}{r^2}$$

(Newton's equation says that you can calculate the gravitational force attracting one object to another by multiplying the masses of the two objects by the gravitational constant and dividing by the square of the distance between the objects' centers.)

Dividing by distance squared means Newton's Law is an *inverse-square law*.

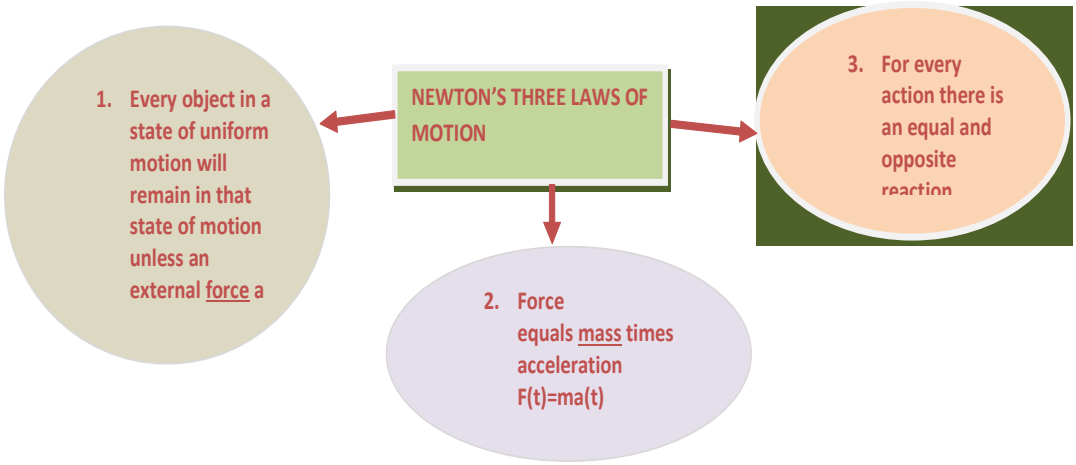
Newton proved mathematically that any object moving in space affected by an inverse-square law will follow a path in the shape of one of the conic sections, the shapes which fascinated ARCHIMEDES and other Ancient Greek mathematicians.

For example, planets follow elliptical paths; while comets follow elliptical, or parabolic or hyperbolic paths.

And that's it! Newton showed *everyone* how, if they wished to, they could calculate the force of gravity between things such as people, planets, stars, and apples.

Newton's Laws of Motion

Newton's three laws of motion still lie at the heart of mechanics.



The first law, also called the **law of inertia**, was pioneered by Galileo. This was quite a conceptual leap because it was not possible in Galileo's time to observe a moving object without at least some frictional forces dragging against the motion. In fact, for over a thousand years before Galileo, educated individuals believed Aristotle's formulation that, wherever there is motion, there is an external force producing that motion.

The second law, F(t)=ma(t), actually implies the first law, since when **f(t) =0** (no applied force), the acceleration **a(t)**is zero, implying a constant velocity **v(t)**. (The velocity is simply the integral with respect to time of **a(t)=i(t)**

Newton's third law implies conservation of momentum. It can also be seen as following from the second law: When one object "pushes" a second object at some (massless) point of contact using an applied force, there must be an equal and opposite force from the second object that cancels the applied force. Otherwise, there would be a nonzero net force on a massless point which, by the second law, would accelerate the point of contact by an infinite amount.

With Newton's calculus, universal gravitation, and laws of motion, you have enough knowledge at your fingertips to plot a course for a spaceship to any planet in our solar system or even another solar system.

And Isaac Newton figured it all out about 300 years before we actually *did* send a spaceship to the planets.

A Word of Caution

Newton's laws become increasingly inaccurate when speeds reach substantial fractions of the speed of light, or when the force of gravity is very large. Einstein's equations are then required to produce reliable results.

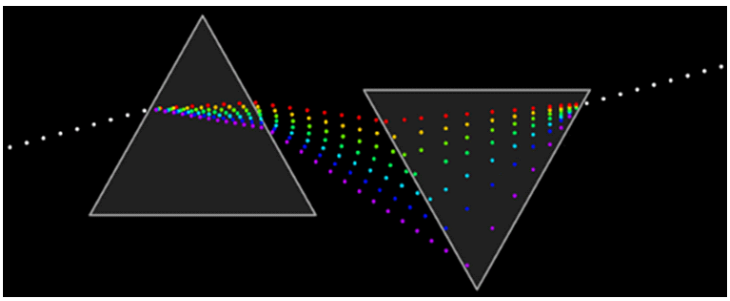
Optics and Light

Newton was not just clever with his mind. He was also skilled in experimental methods and working with equipment.

He built the world's first reflecting telescope. This telescope focuses light from a curved mirror. Reflecting telescopes have several advantages over earlier telescopes including:

- they are cheaper to make
- they are easier to make in large sizes, gathering more-light, allowing higher magnification
- they do not suffer from a focusing issue associated with lenses called chromatic aberration.

Newton also used glass prisms to establish that white light is not a simple phenomenon. He proved that it is made up of all of the colours of the rainbow, which could recombine to form white light again.



(Newton's crucial 1672 experiment with two prisms. The result absolutely demolished competing theories, such as the proposal that glass added the colors to sunlight)

Check Your Progress-1

Note: (a) Write your answers in the space given below.

(b) Compare your answers with the one given at the end of this lesson.

1. The scientific revolution triggered by Copernicus and steered vigorously ahead by Kepler and Galileo was brought to a grand completion by _____.
2. In 1662, _____went to Cambridge for undergraduate studies.

3. Study of _____helps us to understand other sciences such as chemistry, biology, geology.
4. Physics is one of the most_____.
5. Which method presented by Newton using first and last ratios?
6. In which year Bohr was awarded with Nobel prize?
7. Which tract written on about nine sheets which was copied into the Royal Society's Register Book in December 1684?
8. Which masterpiece brought out by Newton that shows work on light and color?

2.4.2 John Dalton (1766–1844)

Born in *September 1766, John Dalton* was an English scientist who did pioneering work in the fields of chemistry and meteorology. He was the *first* ***to publish a paper on color blindness*** and also provided great new insights into the nature of gases. He was renowned during his life though the enormous nature of his contribution was realized with further advancements in science. Here are the 10 major accomplishments of John Dalton including his remarkable contribution to chemistry and meteorology.

Remarkable Meteorological Observations in his First Published Work

Dalton's first major achievements were in meteorology, the scientific study of atmosphere. In 1793, ***Meteorological Observations and Essays*** became his first published work. It asserted for the first time that ***water vapour existed independently in air*** and didn't combine chemically with other atmospheric gases. It also contained his study of ***aurora borealis*** which detected the magnetic relation of the phenomenon and concluded its light to be of purely electrical origin. Dalton made important contributions to meteorology throughout his scientific career and was called the ***Father of Meteorology by John Frederic Danielle.***

John Dalton Published the first ever paper on Colour Blindness

John Dalton was **color blind** and so was his elder brother Jonathan Dalton. In his 1794 paper *"Extraordinary facts relating to the vision of colors"* Dalton described the defect he had discovered in his own and his brother's vision. This paper was the *first publication on color blindness*. Though Dalton correctly recognized that the deficiency was hereditary, his theory regarding it was incorrect. Still color blindness is sometimes referred to as ***Daltonism*** as he was the ***first scientist to thoroughly investigate the defect.***

John Dalton did Pioneering Work in Hydrology

Dalton's 1799 paper proposed after research and estimated calculations that the *quantity of rain and dew are equal to the quantity of water carried off by evaporation and by the rivers. I*t also contained the *earliest definition of the 'dew-point'* and settled for

all practically purposes the controversy over the *origin of springs* by his conclusion that *they are fed by rain.* This paper was an important step in the *development of quantitative hydrological cycles.* Due to John Dalton's contribution, the ***Dalton Medal i***s given to hydrologists by the *European Geophysical Society* for distinguished research in the field.

Provided Great New Insights into the Nature of Gases

In 1802, John Dalton's ground-breaking research, which provided great new insights on the nature of gases, was published. In it he noted correctly that *all gases could be liquefied* provided their temperature was sufficiently low and pressure sufficiently high; and that ***all gases expand the same quantity by heat***. He also came up with what is known as *Dalton's law of evaporation.* It states that the rate of evaporation is proportional to the difference between the saturation vapour pressure at water temperature and the actual vapour pressure in air.

OBSERVED WHAT IS KNOWN AS DALTON'S LAW OF PARTIAL PRESSURES

In 1801, John Dalton found that volume of all gases he studied increased proportionally with rise in temperature when pressure was held constant *(VáT at constant P). T*he law however bears the name of French scientist *Jacques Charles*, who had formulated it earlier but never published the results. In 1803, Dalton published his ***Law of Partial Pressures,*** which states that in a mixture of non-reacting gases, the total pressure exerted is equal to the sum of the partial pressures of the individual gases. Also known as ***Dalton's Law,*** it is commonly applied looking at the pressure of a closed container of gas and water.

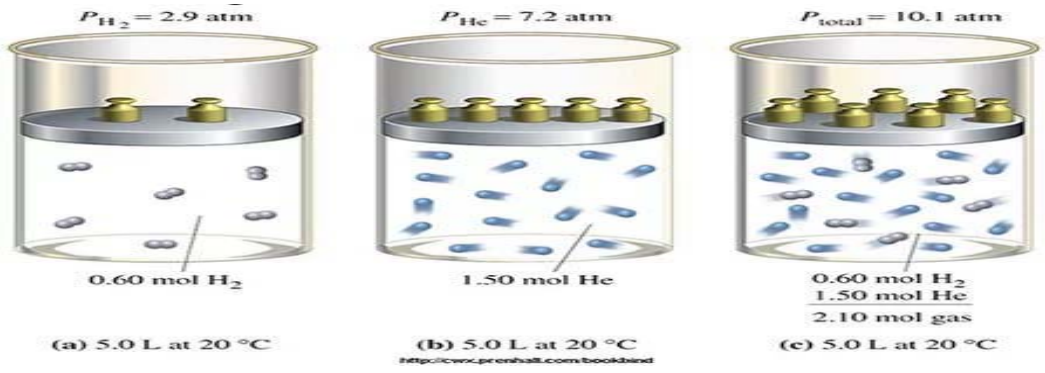


Illustration of Dalton's Law of Partial Pressures

LAW OF MULTIPLE PROPORTIONS IS ONE OF THE BASIC LAWS OF STOICHIOMETRY

Law of Multiple Proportions Demonstrated with Oxygen and 1.00 gram of Nitrogen

Compound	Mass of Nitrogen	Mass of Oxygen
N_2O	1.00 grams	0.571 grams
NO	1.00 grams	1.14 grams
NO_2	1.00 grams	2.28 grams
NO_4	1.00 grams	4.57 grams

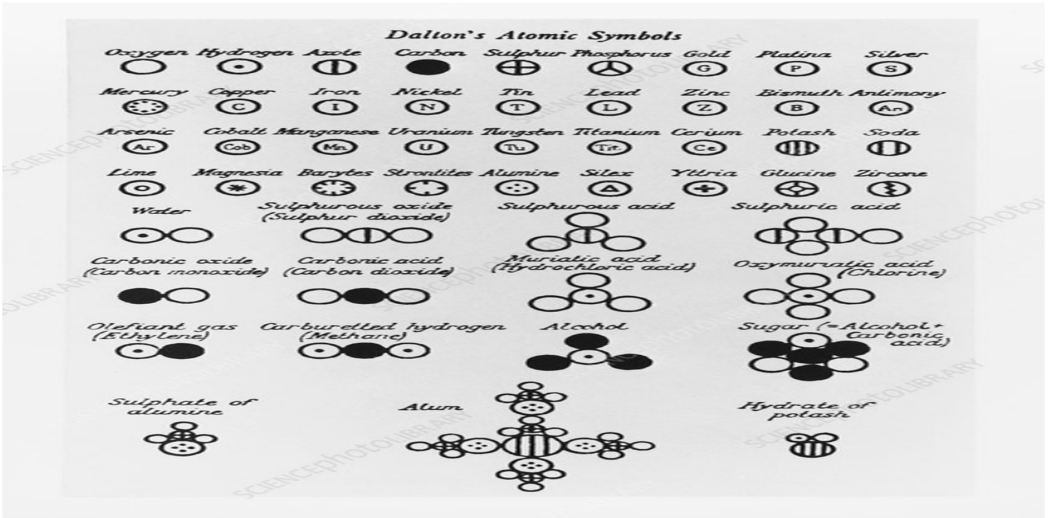
Ratio of Compounds	Ratio of Masses	Ratio	Ratio Small Number
NO_4:NO_2	4.57:2.28	2:1	2
NO_4:NO	4.57:1.14	4:1	4
NO_4:N_2O	4.57:0.571	8:1	8
NO_2:NO	2.28:1.14	2:1	2
NO_2:N_2O	2.28:0.571	4:1	4
NO:N_2O	1.14:0.571	2:1	2
NO_4:NO_2:NO:N_2O	4.57:2.28:1.14:0.571	8:4:2:1	1

Demonstration of Dalton's Law of Multiple Proportions

Two important laws dealing with chemical reactions emerged near the end of the 18th century – *Antoine Lavoisier's law of conservation of mass* and ***Joseph Proust's law of definite proportions***. Through the study of these laws and experimentation John Dalton developed his ***law of multiple proportions***, which states that if two elements can be combined to form a number of possible compounds, then the ratios of the masses of the second element which combine with a fixed mass of the first element will be ratios of small whole numbers. The three laws mentioned above *form the basis of Stoichiometry*, i.e. the calculation of relative quantities of reactants and products in chemical reactions.

PROPOSED THE FIRST TRULY SCIENTIFIC ATOMIC THEORY

Dalton's law of multiple proportions, which he announced in *1803*, became the basis for his famous ***Atomic Theory*** which he *proposed later that year.* The 5 main points of Dalton's atomic theory are: elements are made of extremely small particles called atoms; atoms of a particular element are identical; atoms cannot be created, destroyed or split; atoms of different elements combine in simple whole-number ratios to form chemical compounds; and in a chemical reaction, atoms link to one another, or separate from one another. Dalton's theory was the ***first truly scientific theory of the atom reached through analysis and experimentation.***

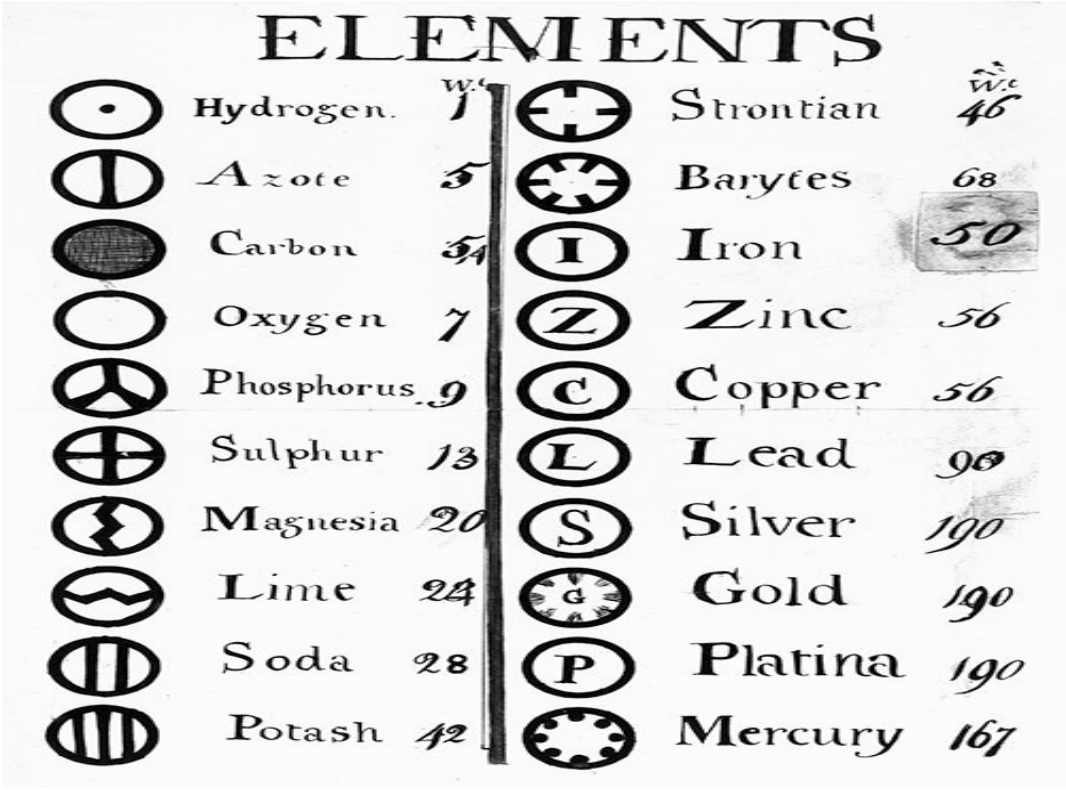


Atoms & molecules by Dalton

DALTON'S ATOMIC THEORY LAID THE FOUNDATION OF MODERN CHEMISTRY

Though later research found that atoms of the same element are not necessarily identical as they can have different masses (isotopes) and that atoms can be split in nuclear reactions; Dalton's atomic theory holds good in several aspects even today and it remains *valid for* ***chemical reactions.*** Also, Dalton's theory *laid* ***the foundation of modern chemistry*** and the basis on which future scientists made numerous other highly significant discoveries.

DALTON WAS THE FIRST TO CALCULATE RELATIVE ATOMIC WEIGHTS



John Dalton's Periodic Table of 20 elements

On the basis of his atomic theory, John Dalton calculated the ***first relative weights of atoms***. He estimated the atomic wei0ghts according to the mass ratios in which they combined; with the hydrogen atom taken as unity. He proceeded to print the ***first published table of relative atomic weights.*** Published in *1803*, his first list contained only 6 elements. This was followed by a 20 elements list in 1808 and a 36 elements list in 1827. In the long run ***atomic weights would provide the key means of organizing elements into the periodic table.***

2.4.3 ALBERT EINSTEIN (1879–1955)

One of the greatest physicists of all time, was born in Ulm, Germany. In 1905, he published three path breaking papers. In the first paper, he introduced the notion of light

quanta (now called photons) and used it to explain the features of photoelectric effect. In the second paper, he developed a theory of Brownian motion, confirmed experimentally a few years later and provided a convincing evidence of the atomic picture of matter. The third paper gave birth to the special theory of relativity. In 1916, he published the general theory of relativity. Some other significant contributions of Einstein are:

- the notion of stimulated emission introduced in an alternative derivation of Planck's blackbody radiation law,
- static model of the universe which started modern cosmology,
- quantum statistics of a gas of massive bosons,
- critical analysis of the foundations of quantum mechanics.
- In 1921, he was awarded the Nobel Prize in physics for his contribution to the theoretical physics and the photoelectric effect.

Einstein's scientific legacy

Einstein's legacy in physics is significant. Here are some of the key scientific principles that he pioneered:

Theory of Special Relativity showed that physical laws are identical for all observers, as long as they are not under acceleration. However, the speed of light in a vacuum is always the same, no matter at what speed the observer is travelling. This work led to his realization that space and time are linked into what we now call space-time. So, an event seen by one observer may also be seen at a different time by another observer.

Theory of General Relativity: This was a reformulation of the law of gravity. In the 1600s, NEWTON formulated three laws of motion, among them outlining how gravity works between two bodies. The force between them depends on how massive each object is, and how far apart the objects are. Einstein determined that when thinking about space-time, a massive object causes a distortion in space-time (like putting a heavy ball on a trampoline). Gravity is exerted when other objects fall into the "well" created by the distortion in space-time, like a marble rolling towards the large ball.

Einstein's legacy for astronomy

There are many applications of Einstein's work, but here are some of the most notable ones in astronomy:

Gravitational Waves: In 2016, the Laser Interferometer Gravitational-Wave Observatory (LIGO) detected space-time ripples — otherwise known as GRAVITATIONAL WAVES — that occurred after black holes collided about 1.4 billion light-years from Earth. LIGO also made an initial detection of gravitational waves in 2015, a century after Einstein predicted these ripples existed. The waves are a facet of Einstein's theory of general relativity.

Mercury's Orbit: Mercury is a small planet orbiting close to a very massive object relative to its size — the sun. Its orbit could not be understood until general relativity showed that the curvature of space-time is affecting Mercury's motions and changing its orbit. There is a small chance that over billions of years, Mercury could be ejected from our solar system due to these changes (with an even smaller chance that it could collide with Earth).

Gravitational Lensing: This is a phenomenon by which a massive object (like a galaxy cluster or a black hole) bends light around it. Astronomers looking at that region through a telescope can then see objects directly behind the massive object, due to the light being bent. A famous example of this is Einstein's Cross, a quasar in the CONSTELLATION PEGASUS: A galaxy roughly 400 million light-years away bends the light of the quasar so that it appears four times around the galaxy.

Black Hole: In April 2019, the Event Horizon telescope showed the first-ever IMAGES OF A BLACK HOLE.The photos again confirmed several facets of general relativity, including not only that black holes exist, but also that they have a circular event horizon — a point at which nothing can escape, not even light.

Photoelectric effect: Einstein's work in 1905 proposed that light should be thought of as a stream of particles (photons) instead of just a single wave, as was commonly thought at the time. His work helped decipher curious results scientists were previously unable to explain.

Unified Field Theory: Einstein spent much of his later years trying to merge the fields of electromagnetism and gravity. He was unsuccessful, but may have been ahead of his time. Other physicists are still working on this problem

2.4.4 NIELS BOHR (1885–1962)

A Danish physicist received his Ph.D. from the University of Copenhagen in 1911. He then spent a year with JJ Thomson and Ernest Rutherford in England.

- In 1913, he returned to Copenhagen where he remained for the rest of his life. He contributed to atomic structure and quantum mechanics.
- In 1920, he was named Director of the Institute of Theoretical Physics. After first World War, Bohr worked energetically for peaceful uses of atomic energy.
- Bohr was awarded the Nobel Prize in Physics in 1922 in recognition of his work on the structure of atoms.
- He received the first *Atoms for Peace* award in 1957. He presented his work in 115 publications; three appearing as books in English: *The Theory of Spectra and Atomic Constitution,* University Press, Cambridge (1922); *Atomic Theory and the Description of Nature,* University Press, Cambridge, 1934; *The Unity of Knowledge,* Double day & Co., New York, 1955.

- A liquid drop would, according to this view, give a very good picture of the nucleus. This so-called *liquid droplet theory* permitted the understanding of the mechanism of nuclear fission, when the splitting of uranium was discovered by Hahn and Strassmann, in 1939, and formed the basis of important theoretical studies in this field (among others, by Frisch and Meitner).
- Bohr also contributed to the clarification of the problems encountered in quantum physics, in particular by developing the concept of complementarity. Hereby he could show how deeply the changes in the field of physics have affected fundamental features of our scientific outlook and how the consequences of this change of attitude reach far beyond the scope of atomic physics and touch upon all domains of human knowledge. These views are discussed in a number of essays, written during the years 1933-1962. They are available in English, collected in two volumes with the title Atomic Physics and Human Knowledge and Essays 1958-1962 on *Atomic Physics and Human Knowledge*, edited by John Wiley and Sons, New York and London, in 1958 and 1963, respectively.

SCIENTIFIC CONTRIBUTION

DISCOVERED THE BOHR–VAN LEEUWEN THEOREM IN 1911

Niels Bohr worked on his PhD thesis during 1910 – 1911, in which he discovered the *Bohr–van Leeuwen theorem*. Later rediscovered by Dutch physicist *Hendrik Johanna van Leeuwen,* the theorem states that *when statistical mechanics and classical mechanics are applied consistently, the thermal average of magnetization is always zero.* The importance of Bohr's discovery is that classical physics does not allow for such things as paramagnetism, diamagnetism and ferromagnetism, and thus quantum physics is needed to explain these magnetic events. The Bohr–van Leeuwen theorem is useful in several applications including *plasma physics*. *Electro-mechanics* and *electrical engineering* also practically benefit from it.

NIELS BOHR INTRODUCED THE BOHR MODEL OF THE ATOM IN 1913

In 1911, British physicist *Ernest Rutherford* formulated the *Rutherford model of the atom* by which an atom contained a very small charged nucleus orbited by low-mass electrons. Niels Bohr applied *Max Planck's quantum theory* to the Rutherford model to come up with his famous *Bohr model of the atom.* The structure of the Bohr model was similar to that of a solar system with electrons orbiting the positively charged atomic nucleus in fixed orbits. Although the Bohr model has been superseded, *its underlying principles remain valid* and due to its simplicity, it is still taught in classes to introduce students to quantum mechanics.

APPLICATION OF QUANTUM CONCEPT TO THE ATOMIC MODEL WAS REVOLUTIONARY

The major improvement of Bohr's model to the Rutherford model *was the quantum physical interpretation of it, which remains sound. In classical physics, electrons could have any energy while quantum physics restricts the energy of a system to certain discrete values. In the* Bohr model electrons can *only occupy specific orbits of fixed energy* at set distances from the nucleus. Most importantly, *while jumping from one allowed orbit to another, they absorbed or emitted electromagnetic radiation. Bohr model thus offered the explanation of how matter could absorb and emit light.*

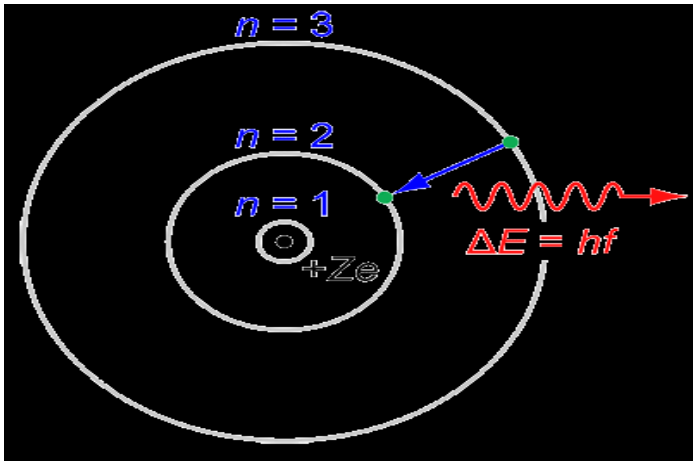


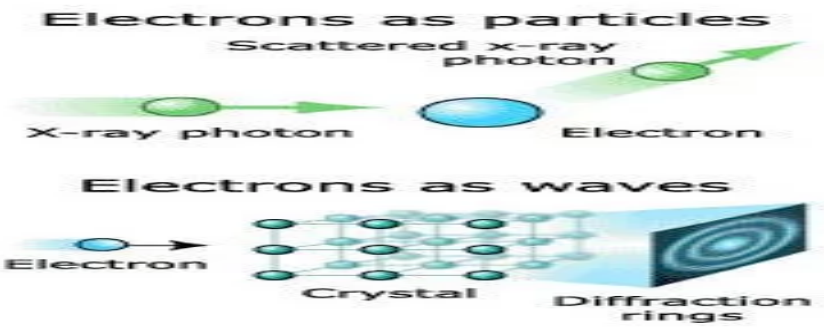
Diagram of Bohr's model of the atom

EXPLAINED THE STRUCTURE OF THE PERIODIC TABLE THROUGH HIS ATOMIC THEORY

Niels Bohr applied his atomic theory to the periodic table of elements. He showed that chemical properties of an element resulted mainly from the behavior of valence electrons, the electrons occupying the highest stable orbit. This was an important step in the creation of the field of quantum chemistry. Also, Bohr predicted that the undiscovered atomic element *72* would resemble zirconium. His prediction was correct and *Hafnium* was discovered in 1923. The element took its name from *Hafnia*, the Latin version of *Copenhagen*, the home town of Bohr.

FORMULATED THE COMPLEMENTARITY PRINCIPLE IN 1927

In 1927, Niels Bohr for the first time formulated the *principle of complementarity*, which states that *on the atomic level a physical phenomenon expresses itself differently depending on the experimental setup used to observe it*. Thus, light appears sometimes as waves and sometimes as particles. Examples of complementary properties thus include *wave-particle duality.* Complementarity, by which complementary properties of an object can't be measured at the same time, *formed the basis of early quantum theory* and is both a theoretical and an experimental result.



Bohr's Complementarity

WITH HEISENBERG AND PAULI, NIELS BOHR DEVISED THE COPENHAGEN INTERPRETATION

Between 1925 and 1927, three leading twentieth century physicists – *Niels Bohr, Werner Heisenberg and Wolfgang Pauli*, devised the *Copenhagen interpretation* of quantum mechanics. By it, *systems at atomic level don't have definite properties prior to being measured.* The act of measurement affects the system and causes it to select one of the various possible values after measurement. This feature is known as *wavefunction collapse.* The Copenhagen interpretation *still provides a conceptual basis for quantum mechanics* and remains among the most prominent interpretations of the theory.

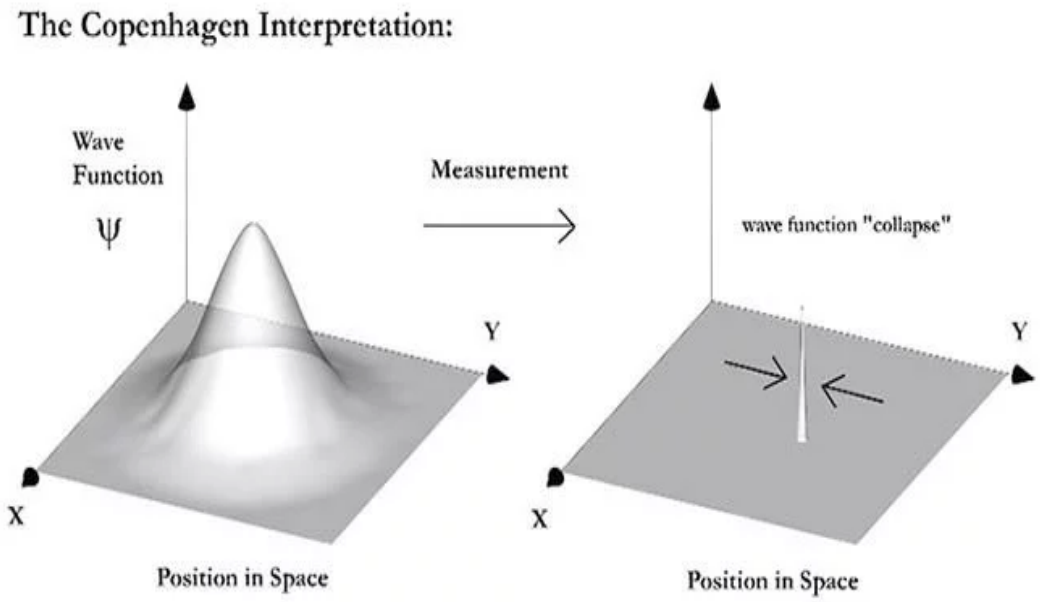


Diagram explaining wavefunction collapse of the Copenhagen Interpretation

THE COMPOUND-NUCLEUS MODEL IN 1936

In 1936, Niels Bohr formulated the Compound-nucleus model. It explained nuclear reactions as a two-stage process. First the bombarding particle becomes an integral part of

a new, highly excited, unstable nucleus, called *a* compound nucleus. The compound nucleus then loses its energy in different ways, such as losing a neutron or emitting gamma rays. The compound-nucleus model is successful in explaining nuclear reactions induced by relatively low-energy bombarding particles. The model was the most prominent description of the process for two decades, till it was improved upon by Niels' son Aage Bohr.

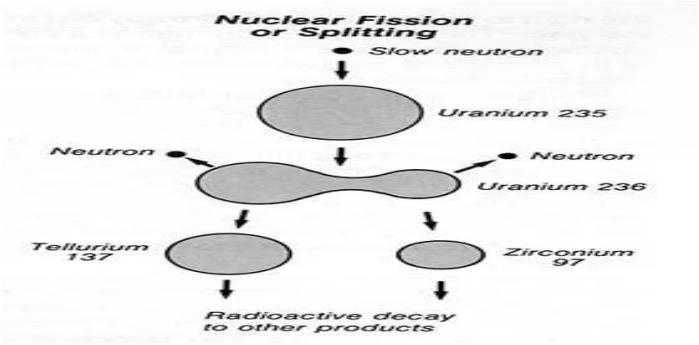


Diagram explaining Liquid Drop model of fission

NUCLEAR FISSION THROUGH HIS LIQUID DROP MODEL

In 1939, Bohr collaborated with American theoretical physicist *John Archibald Wheeler* to develop the *liquid drop model* in nuclear physics to explain the mechanism of *fission*. In the model, the structure of nucleus was like a liquid drop of incomprehensible liquid. Like a drop could be deformed from its basic spherical shape to form two new drops, a large atomic nucleus, like uranium, could fall apart to form two new atomic nuclei. The liquid drop model was a ground-breaking work to explain nuclear fission theoretically.

AN INSTRUMENTAL CONTRIBUTION IN THE DEVELOPMENT OF QUANTUM MECHANICS

He also played an instrumental role in the establishment and development of quantum mechanics, whose applications include light-emitting diodes, the laser, the transistor, semiconductors such as the microprocessor, medical and research imaging, and electron microscopy. It provides explanation for many biological and physical phenomena too.

Check Your Progress: 2

Note: (a) Write your answers in the space given below.

(b) Compare your answers with the one given at the end of this lesson.

1. Which concept was developed by Niels Bohr?
2. In which book Dalton consolidated his theories?
3. _____ discovered a phenomenon in spectroscopy.
4. In 1920, _____was named Director of the Institute of Theoretical Physics. After first World War, Bohr worked energetically for peaceful uses of atomic energy.

5. In 1916, _____ published the general theory of relativity.
6. Which thing gives a good picture to the nucleus, according to NeilBohr?
7. Who had won the 1904 honor in Physics?
8. Who contributed to static model of the universe which started modern cosmology?

2.4.5 Chandrasekhara Venkata Raman (1888–1970)

ChandrasekharaVenkata Raman was born at Thiruvanaikaval, near Trichinopoly, MadrasPresidency to R. ChandrasekharaIyer and ParvatiAmal.

- On February 28, 1928, through his experiments on the scattering of light, he discovered a phenomenon in spectroscopy, later named as the Raman Effect. It was instantly clear that this discovery was an important one.
- It gave further proof of the quantum nature of light. Raman spectroscopy is based on this phenomenon.
- He won the 1930 Nobel Prize in Physics for his work on the scattering of light and for the discovery of the effect named after him.
- In 1934 Raman became the director of the Indian Institute of Science, Bangalore, where two years later he continued as a professor ofphysics.
- Other investigations carried out by Raman were experimental and theoretical studies on the diffraction of light by acoustic waves of ultrasonic and hypersonic frequencies (published 1934-1942), and those on the effects produced by X-rays on infrared vibrations in crystals exposed to ordinary light.
- Raman retired from the Indian Institute of Science in 1948 and established the *Raman Research Institute* in Bangalore, Karnataka a year later. He served as its director and remained active there until his death, at the age of 82.
- The discovery of the Raman effect was a very important discovery in the field of science and helped put India on the map of the scientific world. The significance of the discovery can be gauged from the fact that each chemical compound has its specific molecular signature of scattering and the Raman effect can be used to identify such new compounds.
- Dr. Raman once while on a voyage to Europe, looked at the sea and wondered why it is blue. He subsequently conducted experiments on water and transparent blocks of ice and discovered the reason to be scattering of light. He passed a ray of monochromatic light from a mercury arc through a transparent substance and on observing the spectrum of light so obtained, noticed that some wavelengths of light

had changed. He called this phenomenon Raman scattering which occurred due to the Raman effect. This was further proof of the quantum nature of light.

- **Raman and Rayleigh Scattering**

Lord Rayleigh, who had believed the teen Raman ‘s papers were the work of a professor, had been one in every of the good physicists of his day. He had won the 1904 honour in Physics. His importance to Raman ‘s story is that John William Strutt had been the primary to clarify why the sky is blue. He had then explained the sea ‘s color by location it had been merely a mirrored image of the sky ‘s color. One day, within the summer of 1921, Raman was on the deck of a ship within the Mediterranean the way to the Congress of Universities of nation Empire at Oxford. He checked out the attractive blue color of the Mediterranean and started to doubt Rayleigh ‘s rationalization of its color. Lord Rayleigh had properly explained that the sky appearance blue as a result of a development currently referred to as Rayleigh scattering.

- **Raman Discovers that the ocean Scatters light-weight**

When he sailed back to Republic of India in Gregorian calendar month 1921 Raman, associate tireless individual, had with him some easy physics apparatus: a prism, a miniature optical instrument, and a optical device. He used these to review the sky and therefore the ocean and terminated that the ocean was scattering light-weight. Thus once Lord Rayleigh aforesaid the sea ‘s color is solely a mirrored image of the sky‘s color, he wasn’t completely correct. Raman according his findings in a very letter to the journal Nature. once he came back to his laboratory, Raman associated his students began an thorough going program of analysis into light-weight scattering.

- **The Photon’s Spin**

In 1932 Raman and his student Suri Bhagavatam discovered that photons of light carry angular momentum – in quantum terms, photons possess a property called spin. Light and other forms of electromagnetic radiation pass their angular momentum on to atoms that absorb them.

2.5 LET US SUM UP

- All scientific developments are due to the contributions of great minds in the field of science.
- Newton brought out masterpiece Optics that summarized his work on light and colour.
- John Dalton studied a variety of weather phenomena and about the instruments used to measure them. He is also known for his work on colour blindness.
- Bohr was awarded the Nobel Prize in Physics in 1922 in recognition of his work on the structure of atoms.

- ChandrasekharaVenkata Raman won the 1930 Nobel Prize in Physics for his work on the scattering of light and for the discovery of the effect named after him.

2.6 LESSON END EXCERCISE

1. Define physical science.
2. Name some eminent scientists.
3. Discuss the contribution of CV Raman and Albert Einstein in physical sciences.

2.7 SUGGESTED FURTHER READINGS

Einstein, A. Major Contributions to Science. *The Columbia Electronic Encyclopedia,* 6th ed., Columbia University Press.

Gupta, K. (2018). Contribution to Physics: Sir C. V. Raman. *International Journal of Trend in Research and Development.* Vol. 5(2), 2394-9333.

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Niels Bohr – Facts. Nobel Prize.org. Nobel Media AB 2020. Sat. 6 Jun 2020.

Prabha, S. (2012). Pedagogy of Science (Physical Science). *The National Council of Educational Research and Training(NCERT).*

2.8 ANSWERS TO CHECK YOUR PROGRESS

Answers to Check Your Progress: 1

1. Newton
2. Isaac Newton
3. Physics
4. fundamental science
5. calculus-like method.
6. 1922
7. De MotuCorporumInGyrum
8. Optics.

5. calculus-like method.
6. 1922
7. De MotuCorporumInGyrum
8. Optics.

Answers to Check Your Progress: 2

1. Concept of complementarity
2. New system of chemical philosophy
3. CV Raman
4. Neil's Bohr
5. Albert Einstein
6. A liquid drop
7. ChandrasekharaVenkata Raman
8. Albert Einstien

Lesson No. : 3 **Unit : I**

ROLE OF SCHOOL IN TEACHING OF PHYSICAL SCIENCE

Structure

3.1 INTRODUCTION

According to Kothari Commission (1964-66), the science education is in bad shape and it becomes worse if we fail to reckon with the exclusion of knowledge to meet his immediate feet the recommended upgrading school curricula by research in curriculum development the division of the textbook and teaching-learning material.

This observation indeed highlights the importance and role of school in educating children in science in general and physical science in particular. Physical science is dynamic, expanding body of knowledge covering ever new domains of experience. It is an organised system of knowledge which is based on inquiry born out of natural curiosity, logical

reasoning and experimentation. School is a place where teachers, under a preplanned curriculum and examination system, provide specific doses of knowledge and experiences to the students.The role of school has evolved in recent years from that of a place for transmitting knowledge to one of facilitating knowledge and creating appropriate conditions for learning. Through teacher school is also expected to be a participant in the construction of knowledge and to develop in students an understanding of the nature of science.

3.2 OBJECTIVES

After going through this lesson, you shall be able to:

- describe the meaning of school.
- describe the objectives of teaching of physical science.
- explain the role of school in teaching of physical science.
- expound the professional qualities and professional growth of a physical science teacher.

3.3 MEANING OF SCHOOL

A school is an educational institution designed to provide learning spaces and learning environments for the teaching of students (or "pupils") under the direction of teachers. The School is the Formal agency of Education. It is specialised agency which has become quite importance for culture and civilisation. It is one of the most important, active, direct and formal agencies of education.

The word *school* derives from Greek word *scholç*, or Latin word *schola*originally meaning "leisure" and also "that in which leisure is employed", but later "a group to whom lectures were given, school". The history of ancient civilizations of India, Greece, China and Egypt reveals that material prosperity increased as a result of which the people belonging to the upper class found leisure time. They developed special institutions to educate themselves, and spent their leisure time profitably. The institution that developed out of surplus economy is known as school. In ancient India, we had schools like Guru Ashram, Gurukula, the Vihar, the Sangha, the Pathsala and the Vidyapeeth which preserved and promoted the rich cultural heritage of our country. We called school in the name of Maktabs and Madrasas during the medieval period. The modern school system developed with the advent of the British to our country.

The word 'school' has been defined by different thinkers, educationists and sociologists in different ways. John Dewey defines school as a special environment where a certain quality of life and certain types of activities and occupations are provided with the object of securing the child's development along desirable lines.

An important definition by Ottaway views that the school may be regarded as a social invention to serve society for the specialized teaching of young.

According to J.S. Ross, "Schools are institutions developed by civilized man for the purpose of aiding in the preparation of the young to be well-adjusted and efficient members of the society."

According to K.G. Saiyidain, "The school is a centre of vigorous life. It is in direct intimate contact with the realities of the life around, reflecting the best and worthiest of its features which are simple enough to appeal to the child."

Today, school has been used an important instrument to preserve and strengthen the cultural heritage of our society. It plays a very significant role in discovering and moulding the innate capacities, attitudes, habits and ideas of the children with a view to producing well balanced personalities, who are aesthetically rich, culturally refined, emotionally stable, mentally alert, morally good, physically strong, socially efficient and spiritually enlightened.

Thus a school is an institution designed to provide learning spaces and learning environments for the teaching of students (or "pupils") under the direction of teachers. Thus the following characteristics of a school can be derived:

1. It is a special environment for teaching-learning process.
2. It is an institution by which direct contact between educators and educands is created.
3. It provides life related activities and experiences to students that make the quality of life better.
4. It establishes civilized societies by preparing young children and adults to get adjusted in the society.
5. It develops the child along a desirable line with the help of social activities and experiences.
6. It makes students efficient and productive members of the society.
7. It imparts knowledge to all students regardless of their caste, religion, sex, place, economic conditions etc.
8. It works on the principle of the general welfare of the people.
9. The role of school and its aims change with the change and demand of the time.
10. It is a social institution established by the society for the society. Its fundamental character is determined by the society.

3.4 AIMS AND OBJECTIVES OF TEACHING OF PHYSICAL SCIENCE

An objective is an intent communicated by a statement describing a proposed change in learner of what learner is to like when he has successfully completed a learning experience. As per UNESCO Planning Commission (1964), the teaching of science objectives should be worked on the problems of science education in India and suggested ways to improve it. The following are the objectives of teaching of physical science at school level:

1. To provide practical knowledge of the subject matter content.
2. To provide the latest knowledge to develop scientific knowledge, scientific appreciation and scientific temper among students.
3. To encourage them to learn about nature to develop the love for nature and try to conserve the natural resources and prevent pollution.
4. To develop desirable scientific attitude and values like cooperation, team spirit, fellow-feeling, leadership, courage, truthfulness, honesty and sincerity.
5. To use scientific method i.e. problem, hypothesis, experiment, a conclusion in decision making.
6. To develop the competency to apply his/her knowledge to the solution of problems around him/her.
7. To impart the knowledge to the students about the world, the importance of science and its effects on society and its environment.
8. To work according to scientific method and develop the scientific views.
9. To develop the critical thinking, logical reasoning, open-mindedness and a desire for accurate knowledge among students.

3.5 ROLE OF SCHOOL IN TEACHING OF PHYSICAL SCIENCE

From the meaning of school and objectives of physical science, it is easy to establish the role of school in teaching of physical science. School is an institution where learning spaces and learning environments for teaching of students are provided under the direction of teachers. The role of school can be explained in terms of the facilities it provides for developing an adequate environment for teaching of science to students.

Schools should have a sound management system which involves the participation of various stakeholders, including teachers and parents etc. The school management should also establish a good management culture to facilitate the professional development of teachers and create a harmonious school atmosphere. Schools should also formulate reasonable objectives and provide students with a proper learning environment where in the objectives of physical science can be realised. They should offer students balanced learning opportunities in the five aspects of development, i.e. moral, intellectual, physical, social and aesthetic as well as nurture them to be responsible citizens. Finally, schools should be self-directed, flexible and seek for continuous improvement and development in order to meet the needs of the community. The following points highlight the role of school in teaching of physical science:

Recruiting teachers with scientific aptitude

Science teacher should be fair and scrupulous to all and not act out of her vested

interest. She should be appreciative of our composite culture and national identity from an international perspective. School authorities should recruit such teachers who are up to date in the area of latest development in science, technology, their impact on the society and have scientific aptitude.

Procuring adequate laboratories facilities for carrying out experiments

School plays an important role in teaching of physical science by providing adequate laboratories facilities and procuringchemicals and instruments for carrying out experiments. The management of the school or the head of the school must ensure that enough resources are there in the school to teach physical sciences to the students.

Providing flexibility to teachers to apply innovative methods

A good school should give flexibility to science teachers to transact physical science curriculum in the best possible and innovative ways. Financial and other administrative hurdles should not be there in the way of physical science teachers.

Celebrating important days of scientific/ environmental importance

School should celebrate important days of scientific/ environmental importance. National Science Day, World Water Day, International Earth Day, World Environment Day and other such days should be celebrated by organizing seminar, symposia, debate, declamation, etc.

Organising field trips and excursions to places of scientific importance

Organisation of science exhibition, science club, science drama, excursions, field visits and other new ways of getting scientific knowledge must be done. All students should be motivated to participate in the organisation and execution of such activities.

Encouraging teachers and students to pursue projects of scientific interest

School is a place where the essence of scientific interest is sown. So, school must encourage its teachers and students to pursue projects of scientific importance.Engaging young students with exciting material and experiences motivates them to learn and pursue the sciences throughout school.

Demonstrating unbiased behavior towards everyone

Schools should demonstrate unbiased behavior towards every one (whether students or teachers). Unbiasedness is an important characteristic of physical science. This quality can be imbibed among students from the school itself.

Honouring the diversity

To assure educational excellence for all students, schools must appreciate the diversity that students bring to the environment and organise schools and classrooms in

such a way that the overall development of all students is ensured. Educational environments need to be created that honour diversity and respect of each individual.

To develop logical thinking

The individual should develop scientific temper through logical discussion and application of scientific method and inquiry. The school should provide ample opportunities for developing logical thinking among students.

Finding solutions for problems scientifically

Through experimentation, school should try to find the solutions for problems. In scientific inquiry, every decision we make is based on answers of questions (What is the problem?), constructing a hypothesis (How do I solve it?), testing it with evidence and evaluating the result (Did the solution work?), and making future decisions based on that result.Problem-solving is one of the most important skills students learn in school. They are essential to making good decisions that lead to achievement and success during and after school.

Developing critical thinking

It is important to develop critical thinking in them to maintain a healthy and sustainable society. Children need to be encouraged to appreciate and participate in the responsible use of science and technology for the benefit of society. They should also have a scientific vision about different issues and abilities to acquire and process information about scientific and technological developments relevant to their everyday life and their long-term implications on society.

Linking scientific knowledge with day to day living

Education is sometimes blamed for bringing about an alienation of the child from the family, society and day to day living. This problem could be addressed by transacting curriculum in such a way that there is a close connection among the daily life activities, local environment and the learning of scientific knowledge by the child.

Producing responsible citizens of the country

Students need to be encouraged to visualise future of our nation to become responsible citizens. Students should be made aware about interrelationship and interdependence of various scientific issues in the global and economic contexts so that they can form a wider perspective of justice, peace and non-violence.

Promotion of collaboration in place of competition

Social climate of the school and classroom has a deep influence on the learning process of the learners. An atmosphere of trust would make the classroom a safe space where students can share their experiences, where conflict can be acknowledged and

constructively questioned, and where resolutions, however tentative, can be mutually worked out. Collaboration in all forms rather than competition should be promoted.

Help fighting prejudices

School should use science learning as an instrument of social change to reduce the socio-economic divide. It should help fight prejudices related to gender, caste, religion and region. Science education ought to empower students to question the social beliefs, notions and practices that perpetuate social inequality. Equitable educational systems foster the maximum development of individual potential. A commitment to equity ensures that all children have access to quality education; they develop knowledge and skills needed to participate effectively in community life as workers, citizens, parents, leaders and role models for future generations.

Being sensitive and responsive to gender related issues

No gender bias should be practised in the school/ classroom and in allotting scientific work to the students. All attempts should be made to motivate the parents to encourage their girl children to opt for science. Teachers, teacher educators, textbook writers and educational administrators must be made sensitive and responsive to gender-related issues. Problems and exercises, as well as texts that reflect the reality of women's life and experiences should be an integral part of teaching-learning experiences. Laboratory work that highlights scientific dimensions of domestic work also, for example chemistry in kitchen should be taken into account.

Making students sensitive towards environmental issues

We have transformed ourselves into knowledge beings and by our activities, we brought about changes in the environment. These activities have resulted in pollution of the environment. Of late, pollution has started increasing at an alarming rate. It is very important role of the school to make students sensitive towards the effects of contaminants on the environment.

Establishing peace in the society and nation

School can help in establishing peace in the society by the developing a feeling of welfare of the human life as a prime concern.The individual should appreciate that scientific development for the benefit of humanity takes place when there is peace all around.Scientific knowledge and its developmental enterprises must be used for the welfare of humankinds which in turn would bring peace in the society.

Understanding the effects of contaminants on the environment

The school must enable the students to understand the effects of contaminants on the environment andalternatives to be used causing minimum or no-pollution should be told tostudents.For example, alternative sources of energy such as wind, solar, nuclear,

biogas, tides, geothermal, etc. have been explored and their use is growing. Such measures would surely decrease pollution and the global warming.

Thus, school helps in realizing the objectives of teaching of physical science.

Check Your Progress-1

Note: (a) Answer the questions given below.

(b) Compare your answers with those given at the end of this lesson.

1. The term 'school' has been obtained from the Greek word
   (a) schole
   (b) school
   (c) skool
   (d) skole
2. Which of the following is true:
   (a) Teaching of physical science leads to the development of critical thinking and problem-solving ability among students.
   (b) Teaching of physical science gives students the skills and knowledge they need to succeed in school and beyond.
   (c) School should breed a culture of arrogance.
   (d) School should promote the professional development of teachers.

3.6 PROFESSIONAL QUALITIES OF A PHYSICAL SCIENCE TEACHER

Good physical science teaching is one of the most valuable means to meet the needs of the educated citizens and workers. Every teacher wants to be good, but what exactly are the qualities that make a good physical science teacher. So, the following are the some of the professional qualities to be possessed by a physical science teacher:

1. **Planning of the lesson in advance:** There is a famous proverb, "if you fail to plan, you plan to fail." This holds extremely true in case of a physical science teacher. To plan before hand is an important quality of a science teacher. A physical science teacher never goes unprepared to the classroom. Infact, he/she plans his/her work for the whole year in advance.
2. **Trained in modern methods and techniques of teaching physical science:** To bring the desirable changes in the students, the teacher's work should be exciting and satisfying. For this, physical science teacher must be trained in modern methods and techniques of teaching physical science.

3. **Source of inspiration:** A good physical science teacher should inspire and prepare the students to investigate the great questions of science and the questions raised by the scientific discovery as it is said, "A poor teacher tells, an average teacher explains, a good teacher demonstrates and a great teacher inspires".

4. **Engages students at a high level:** A science teacher should engage his/her students at a high level. The values of open mindedness, critical thinking, reasoning, objectivity and critical observation cannot be inculcated among students until teacher is able to engage them at the highest level.

5. **Knows students' learning styles:** A good physical science teacher must be aware of his/her students' learning styles so as to adapt his/her teaching as per the needs of the students. This proves to be beneficial for the entire class in improving the learning outcomes.

6. **Brings science lessons to life with real-world applications:** A student develops life-long scientific interest and understands the nature of science and its usefulness to man-kind, if the physical science teacher relates the science lessons with daily life and real-world applications. So, it is an important quality of a physical science teacher to bring science lessons to life with daily life applications.

7. **A good communicator of ideas:** A teacher should be clear in speech and should be able to convey his ideas to his pupils with ease and effectiveness. His black-board and sketching should be quite neat, bold and effective.

8. **Plain speaking:** A physical science teacher by nature should be truth loving and plan speaking. He/she must have enough courage to say the right thing as right and wrong ones as wrong. There should not be any ambiguity in his/her thoughts and saying.

9. **Impartial behavior and attitude:** A physical science teacher should not have any biases and prejudices of any kind towards any of his/her students. He/she should not distinguish and discriminate one people from the other and should try to drop all notions of favouritism or antagonism by giving a solid proof of his/her impartial behaviour and attitude towards all of his/her students.

10. **Hard worker and responsible:** The physical science teacher should be his/her own example of hard work and sincerity. He should inspire his students to acquire a taste for learning, doing safe work as well as sharing responsibilities with all his keenness and sincerity.

11. **Affectionate behaviour:** The physical science teacher should create an atmosphere of good will, love and cooperation in the matter of dealing with his students. He/she should not get irritated on minor faults and mistakes of his/her pupils but should try to create an environment of mutual trust and affection congenial for proper work and learning.

12. **Patience:** A physical science teacher should not lose his patience and unnecessarily get disturbed over minor mistakes and shortcomings of his/her pupils but must demonstrate a lot of patience in dealing with them. On the other hand, the pupils should not always live in constant fear of the teacher but must try to receive proper guidance from their teacher.

13. **Leadership and love for discipline:** The physical science teacher must possess the traits of a good leader in whom the students may have a genuine faith. He/she should be able to inspire the students to seek knowledge with sincerity. A disciplined and sincere teacher will be able to inculcate the values of sincerity, discipline and obedience among students. This will channelize the energy of students towards constructive activities.

14. **Self-confidence:** A teacher must have confidence in his abilities. This confidence must be demonstrated through his behaviour in general and his classroom teaching in particular.

15. **Mastery of his subject:** A physical science teacher should have profound knowledge of his/her subject of study so that he may not cut a sorry figure before his students. He/she should be able to keep his/her head high and be able answer all the questions and problems put to him/her by his students up to their satisfaction in all branches of his subject.

16. **Knowledge of other subjects:** A physical science teacher should not only be an expert in his subject but should also have a good working knowledge of the other related subjects. For example, the physics teacher should have good knowledge of Mathematics and Biology teacher should know much about chemistry in order to do more justice with his teaching. Moreover, a teacher equipped with the essential knowledge of the all related subjects will able to handle his students efficiently as the subjects of the curriculum are supplementary to each other in fulfilling the objectives of teaching at a particular stage and the application of one subject is easily found in the other.

17. **Scientific thinking and attitude:** A good physical science teacher tries to imbibe scientific thinking and attitude in his own actions thoughts. For imbibing of such traits, a science teacher must attempt to provide science education in such a way as to inculcate in the pupils a habit of testing the validity of certain beliefs and facts by their own independent observations and experimentation.

18. **Efficiency in the preparation and use of teaching aids:** The science teacher should have sufficient skill and dexterity in improvising and constructing his own aids in teaching of science according to the local needs and situations. Needless to say that he should have full self- confidence in handling all types of demonstration equipments

and materials as well as in using all types of audio visual aids for making the science teaching as effective as possible.

19. **Taste of scientific activities:** A good science teacher should have taste and love for organizing and participating in scientific activities like establishment of science museum and science club, organising scientific excursions and science fairs and engaging in the purposeful scientific hobbies. Such activities constitute real education and help in the proper development of scientific attitude among the students.

20. **Knowledge of psychology related to science:** The physical science teacher should have knowledge of the science of behaviour of his students in order to handle them effectively in the teaching-learning process. He should try to impart knowledge and skills to then according of their mental abilities, capacities, interests and attitudes, as well as emotional and social make up.

Check Your Progress-2

Note: (a) Answer the questions given below.

(b) Compare your answers with those given at the end of this lesson.

1. Which of the following statement/s is/are true/ false:

(a) A physical science teacher must plan his/her work beforehand. (T/F)

(b) To develop critical thinkingability among students, a physical science teacher must demonstrate this ability in him/her. (T/F)

(c) It is not required for a physical science teacher to know his/her students. (T/F)

(d) A physical science teacher should not have knowledge about other related subjects. (T/F)

(e) A physical science teacher should have sufficient skill and dexterity in improvising and constructing his own aids in teaching of science according to the local needs and situations. (T/F)

(f) It is an important quality of a physical science teacher to bring science lessons to life with daily life applications. (T/F)

3.7 PROFESSIONAL GROWTH OF A PHYSICAL SCIENCE TEACHER

Good physical science teachers make a commitment to keep their science education current by taking advantage of professional development opportunities. In addition to training provided onsite and offsite at the school, highly effective science teachers will be just as committed to their own learning as to their students. Understanding the latest

instructional topics such as scientific misconceptions/alternative conceptions, logical-mathematical and scientific reasoning and motivation are among the benefits of the getting higher qualifications and attending professional development programmes.

Professional growth essentially refers to gaining new skills and work experience that can help a physical science teacher to reach a goal in his/her career. And since we're going through an ever-changing job market, keeping ourselves up-to-date with trends will give usa better chance to distinguish ourselves among others for years to come.

As OECD's (Organisation for Economic Co-operation and Development) comparative review on teachers noted (OECD, 2005):

Effective professional development is on-going, includes training, practice and feedback, and provides adequate time and follow-up support. Successful programmes involve teachers in learning activities that are similar to ones they will use with their students, and encourage the development of teachers' learning communities. There is growing interest in developing schools as learning organisations, and in ways for teachers to share their expertise and experience more systematically.

The development of teachers beyond their initial training can serve a number of objectives (OECD, 1998), including:

- to update individuals' knowledge of a subject in light of recent advances in the area;
- to update individuals' skills, attitudes and approaches in light of the development of new teaching techniques and objectives, new circumstances and new educational research;
- to enable individuals to apply changes made to curricula or other aspects of teaching practice;
- to enable schools to develop and apply new strategies concerning the curriculum and other aspects of teaching practice;
- to exchange information and expertise among teachers and others, e.g. academics, industrialists; and
- to help weaker teachers become more effective.

To examine these issues, The Teaching and Learning International Survey (TALIS) adopts a broad definition of professional development among teachers:

"Professional development is defined as activities that develop an individual's skills, knowledge, expertise and other characteristics as a teacher."

The definition recognizes that development can be provided in many ways, ranging from the formal to the informal. It can be made available through external expertise in the form of courses, workshops or formal qualification programmes, through collaboration

between schools or teachers across schools (e.g. observational visits to other schools or teacher networks) or within the schools in which teachers work. In this last case, development can be provided through coaching/mentoring, collaborative planning and teaching, and the sharing of good practices.

Different Types of Programmes for Professional Growth

For professional growth of teachers, the following are some of the activities in which they can participate:

- Orientation programmes (for newly inducted teachers)
- Refresher Courses (for experienced teachers)
- Action Research (for solving the immediate classroom/ school problems)
- Courses/workshops (e.g. on subject matter or methods and/or other education-related topics);
- Education conferences or seminars (at which teachers and/or researchers present their research results and discuss education problems);
- Qualification programme (e.g. a degree programme);
- Observation visits to other schools;
- Participation in a network of teachers formed specifically for the professional development of teachers;
- Individual or collaborative research on a topic of professional interest; and
- Mentoring and/or peer observation and coaching, as part of a formal school arrangement.

Science education is broader than the classroom and a good science teacher works to ensure colleagues are current about the latest systemic teaching methods. By helping the school as a whole to be successful, a good science teacher is strengthening the country's economy and competitiveness.

Check Your Progress-3

Note: (a) Answer the questions given below.

(b) Compare your answers with those given at the end of this lesson.

1. Which of the following programmes does not fit appropriately to be called as the programmes for professional growth among physical science teachers?

   (a) Orientation Programme

   (b) Refresher Course

   (c) Gossip

(d) Action Research

2. Which of the following statement/s is/are true/ false:

(a) Good physical science teachers make a commitment to keep their knowledge current by taking advantage of professional development opportunities. (T/F)

(b) A good science teacher works to ensure colleagues are current about the the latest systemic teaching methods. (T/F)

(c) Professional growth essentially refers to gaining new skills and work experience that can help a physical science teacher to reach a goal in his/ her career. (T/F)

(d) Orientation programmes are organized for the experienced physical science teachers. (T/F)

(e) By attending professional development programmes, the physical science teachers can improve and construct their own aids according to the local needs and situations. (T/F)

(f) A physical science teacher does not help in strengthening the economy of his/her country. (T/F)

3.8 LET US SUM UP

- School should use science learning should be used as an instrument of social change to reduce the socio-economic divide. It should help fight prejudices related to gender, caste, religion and region.
- School ought to empower students to question the social beliefs, notions and practices that perpetuate social inequality.
- School plays an important role in developing knowledge and skills among students which are needed to participate effectively in community life as workers, citizens, parents, leaders and role models for future generations.
- To assure educational excellence for all students, schools must appreciate the diversity that students bring to the environment and organise schools and classrooms in such a way that the overall development of all students is ensured.
- Educational environments need to be created that honour diversity and respect of each individual.
- The school should display conviction and mobilise required resources to put in place support systems that will help these children to overcome their inadequacies in learning science in a meaningful manner.

- School should appreciate that science being a study of nature, does not have any scope for such biases.
- School should use science curriculum as an instrument of social change to reduce the socio-economic divide and to help fight prejudices related to gender, caste, religion and region.
- In the activities of the science clubs, all students should be encouraged to participate in visits to exhibitions, museums or science parks.
- During practical work, importance should be given to all students irrespective of gender, religion, caste, colour, etc.
- School must promote collaboration and stronger connection between different classes of the school, various schools, with other educational institutions and in general with communities to help develop a healthier society.
- Science exhibition, science club, science drama, field visit to various places and out of the school activities should be promoted to foster social values along with enrichment of educational experiences.
- School should be fair and scrupulous to all and not act out of any vested interest. It should be appreciative of our composite culture and national identity from an international perspective.
- School should keep its teachers and students up to date in the area of latest development in science, technology and their impact on the society.
- Developing scientific attitude in students is one of the important obligations of school.
- Physical science teachers should demonstrate the qualities of hard work, commitment, sincerity, dedication, quest for knowledge and life-long learner.
- To keep themselves abreast with the latest advancements in field of physical science, teachers must participate in different professional development programmes.

3.9 LESSON END EXERCISE

Q.1. What do you mean by the term school?

Q.2. What are the characteristics of a school?

Q.3. Describe the role of school in teaching of physical science.

Q.4. Expound the professional qualities of a physical science teacher.

Q.5. Write a short note on professional growth of a physical science teacher.

3.10 SUGGESTED FURTHER READINGS

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3.11 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress-1

1. (a) schole

2. (a) True (b) True (c) False (d) True

Check Your Progress-2

1. (a) True (b) True (c) False (d) False (e) True (f) True

Check Your Progress-3

1. (c)

2. (a) True (b) True (c) True (d) False (e) True (f) False

Lesson No. : 4 **Unit : II**

AUDIO - VISUAL AIDS

Structure

4.1 INTRODUCTION

The development of humanity is totally dependent upon how humans grow and learn to grow. The process of growth and development depends much upon heredity and environment. The heredity is the base of the innate qualities of the humans whereas

environment grows and develops these innate qualities upto their inherited potential. The environment induces learning both in formal and informal settings. The process of learning is dependent upon so many factors which helps in grooming of personality. The personality develops as the result of interaction of the individuals with the environment through all the sensory organs. These sensory organs are the gateways to learning. Learning is a process which is responsible for shaping the behavior and hence personality of the individual. The effective and accomplished learning takes place when maximum sensory organs are involved. The teaching of physical sciences specially deals with all inanimate natural objects. The nature of the subject itself suggests that these could be better understood through various teaching aids which can provide a physical and perceptual image of the object/phenomena.

4.2 OBJECTIVES

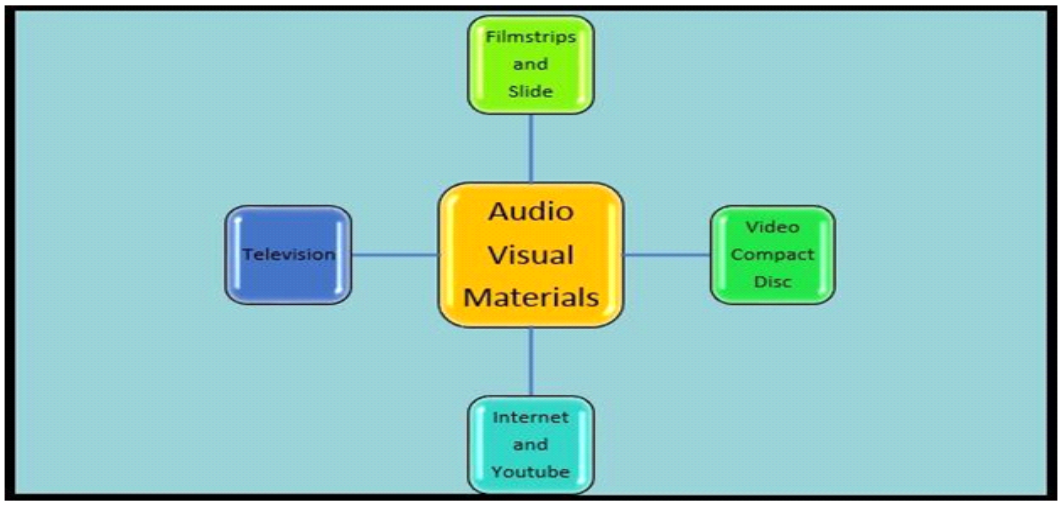
After going through this lesson, you shall be able to:

- explain the meaning of audio-visual aids,
- give the characteristics of audio-visual aids,
- explain the importance of audio-visual aids,
- discuss the various teaching aids and their classification, and
- discuss the various uses of audio visual aids for teaching physical sciences.

4.3 MEANING, CHARACTERISTICS, NEED AND IMPORTANCE OF AV AIDS

The teaching and learning in sciences involve much of observation, experimentation, handling of inanimate objects. All this requires better exposure to the laboratory work, Audio visual experiences and visual presentations by the teacher.

Audio means 'to hear' and Visual stands for 'seeing', so Audio Visual Aids are devices which can be heard as well as seen. AV aids also known as sensory aids, make teaching more interesting and effective. But it must be clearly understood from the very beginning that these aids are to be of help in teaching, not to be a substitute for teaching. Therefore, use of teaching aids does not guarantee good teaching. As they require careful planning and ingenuity on the part of the teacher. There exists a wide variety of audio visual material viz. a viz television, filmstrips, slides, compact disc, youtube, internet etc.



Audio-visual aids can be defined as those tools and devices by the use of which communication of ideas between persons and groups are facilitated in various situations"

According to good's dictionary of education "these aids are anything by means of which learning process may be encouraged or carried on through the sense of hearing or sense of sight."

According to Burton, "audio-visual materials are those sensory objects or images which initiate, stimulate and reinforce learning."

According to Mcknown and Roberts, "audio visual aids are supplementary devices through which the teacher can utilize more than one sensory channel, tries to clarify, establish and correlate concepts, interpretations and appreciations"

Characteristics of Audio-Visual Aids

The AV aids used in teaching involves following characteristics:

- The audio-visual aids help in learning and understanding of the material permanently.
- It reduces verbalism & eliminates language related problems.
- It saves time and increases interest.
- It gives a flow to the thoughts.
- It makes use of a variety of media and senses.
- Develops scientific attitude as it involves observation and handling of devices.
- Gives a chance of learning through comparative study of natural and artificial things.
- The sense of perception is inspired and the students obtain precise knowledge.

Need and Importance

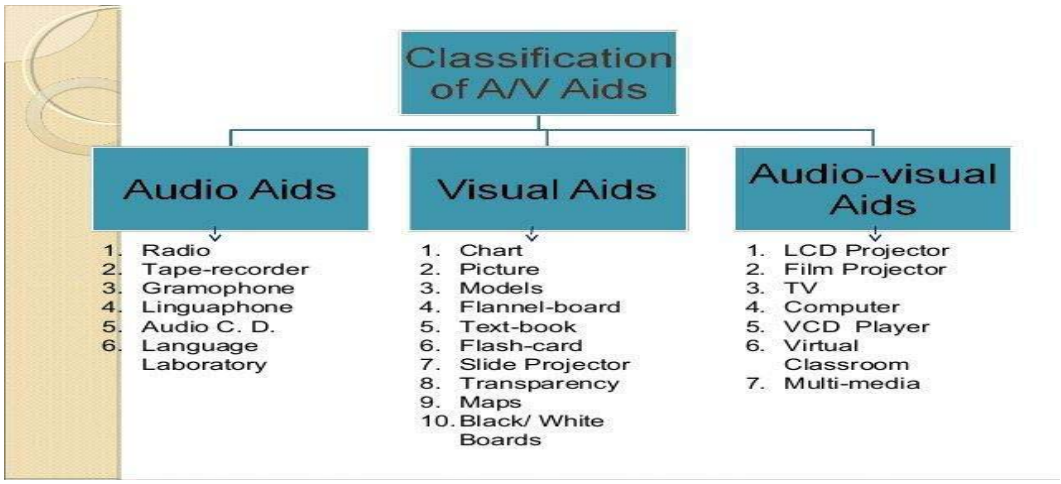
If AV aids are properly used, it increases the amount and length of leaning. Some of the advantages of these aids are given below:

- Help to draw interest: The audio-visual aids help the teacher to win the interest and attention of the pupils. They motivate the students to physical and mental activities.
- Learning becomes effective: They save time and make learning effective and durable. Studies have shown that pupils retain the knowledge gained through these aids, for a much longer time as compared to the subject.
- First-hand experience: They help the pupils to get first hand experience by looking at concrete things, living specimens and actual demonstrations, handling the apparatus and performing the practical themselves.
- To develop scientific attitude: They help the pupils to develop scientific attitudes and get training in scientific methods.
- To teach large numbers: A large number of students can be taught at a time by their use. For example, the use of magic lanterns or epidiascope can be conveniently made for a big audience.
- Change for atmosphere to more interactive: They help to bring a change in the atmosphere of the class. The traditional monotony goes away. For example, when a film strip or slide is shown, the students laugh, talk and pass their comments as they go outside the class.
- To inspire correct thinking: They help the students to inspire correct thinking, for they give actual meaningful associations. In the words of Edgar Dale- "Because audio-visual materials supply a concrete basis for conceptual thinking, they give rise to meaningful concepts-the words enriched by meaningful associations. Hence, they offer the best antidote available for the disease of verbalism."
- Help for clear conception: They help the pupils to have clear conception of ideas, information, facts and principles. Students can have insight and better understanding of various complicated and different topics.
- Teachers become friendly: Through this process, the attitude of the teacher is very friendly. For the purpose of explaining models, showing exhibitions or taking the pupils to outdoor places, the teacher has to be a true friend and guide. The pleasant and natural atmosphere thus created, greatly helps proper learning.
- Based on principles of Psychology: It is the most convenient, easy and natural way of learning, for the use of audio-visual aids is based on the principles of Psychology.

4.4 TYPES OF TEACHING AIDS

Classification 1- The teaching aids can be classified on the basis of sensory organs involved.

All the teaching aids can be grouped under following headings;

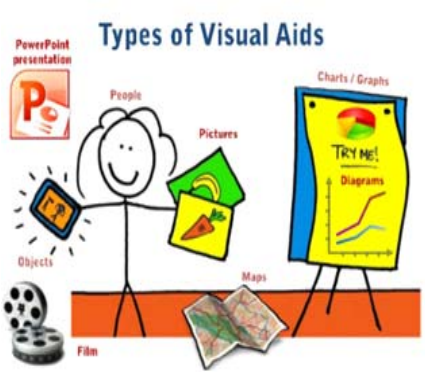


Aural/Audio Aids

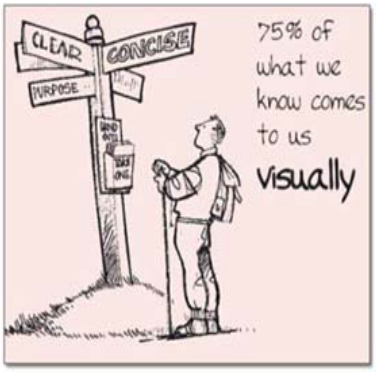
These teaching aids utilize the sense organs of hearing. These aids focuses on developing listening skills among learners. For example radio, gramophone, audio-tapes and gramophone etc.,

Visual Aids

These teaching aids focus on the 'sense of seeing' of an individual by using a variety of media i.e. charts, pictures, maps, models, diagrams, real objects, specimens, flash cards, chalk boards, slides etc. These aids supplement audio with visual effects.



VISUAL AIDS FOR ELLS!



"Something is happening. We are becoming a visually mediated society. For many,understanding of the world is being accomplished, not through words, but by reading images" (Lester, 2006)

Audio-Visual Aids

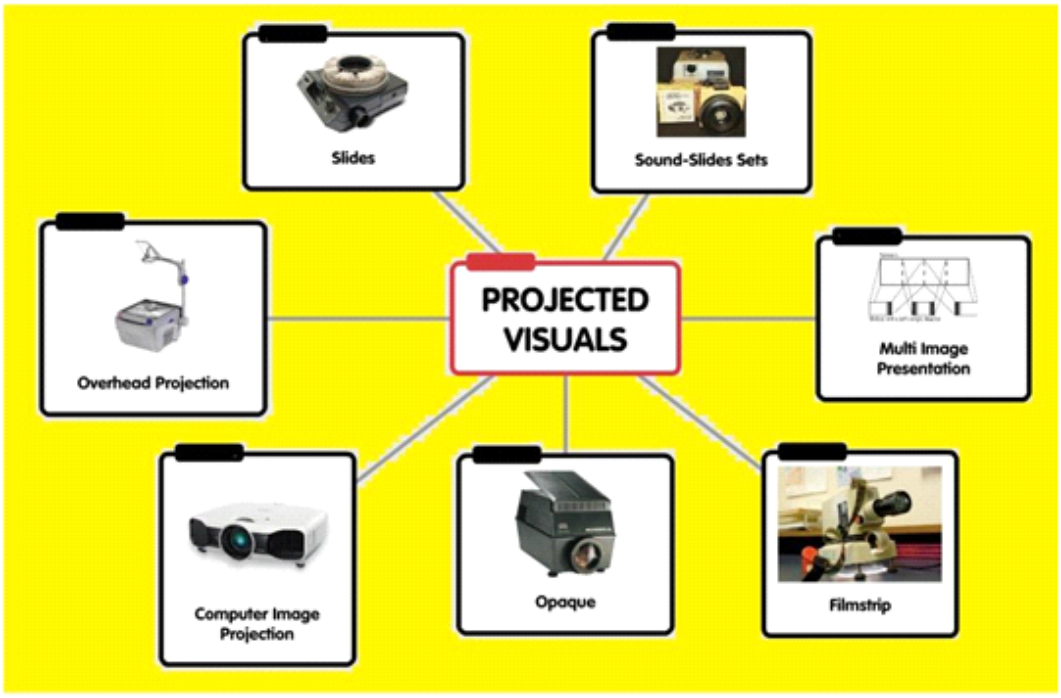
In this category, those aids are included which utilize both the senses of seeing and hearing simultaneously. They include optical aids (including sound films- projectors) and television.

4.5 CLASSIFICATION OF TEACHING AIDS IN SCIENCES

Category 1—Classified on the use of hardware

In sciences teaching aids can be classified as projected and non projected.

Projected Aids- It includes all the optional aids or machines which project the image of the given object like picture, map, sketch, slides or written paper, on the screen or wall as shown in the figure below;



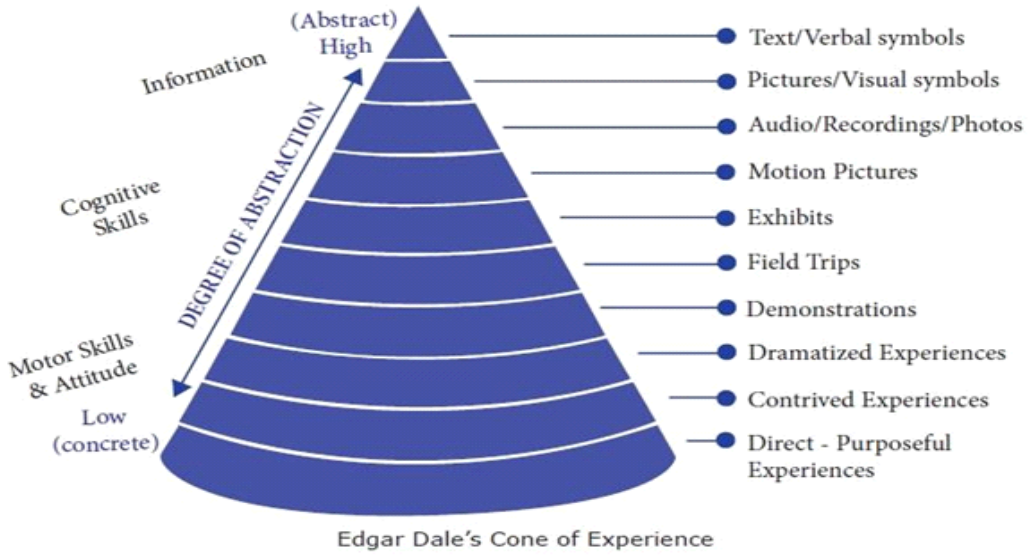
Examples of projected aids are: overhead projector, film projector, film strip projector, micro projector, epidiascope etc.

Non-Projected Aids - It includes all teaching aids which do not project the image of the given object. So these aids don't require any projector or projection screen. For example chalkboard (black board), tape records, television, museum, aquarium, models, flannel graph, pictures etc.

Category -11—classified on the amount of doing and gaining experience

Edgar Dale has classified teaching aids by using cone of experience. He emphasised on the fact that learners retain more information "by doing" rather than what they "read", "listened" or "observed". Nowadays, this "learning by doing" is known as "experiential learning" or "action learning".

Dales' cone of experience is a tool to help instructors make decisions about resources and activities.



Edgar Dale's Cone of Experience

The instructor can ask the following:

- Where will the student's experience with this instructional resource fit on the cone? How far is it removed from real-life?
- What kind of learning experience do you want to provide in the classroom?
- How does this instructional resource augment the information supplied by the textbook?
- What and how many senses can students use to learn this instructional material?
- Does the instructional material enhance learning?

Check Your Progress-1

Note: (a) Answer the questions given below.

(b) Compare your answers with those given at the end of this lesson.

1. AV aids are also known as _____ and make teaching more interesting and effective.
2. Which of the following is not an example of aural aids?

   A. Radio

   B. Flash card

   C. Gramophone

   D. Audio-tapes

3. _____ has classified teaching aids by using cone of experience.
4. Name any two projected aids.

5. Write any two characteristics of AV aids.

4.6 USE OF AV AIDS FOR TEACHING OF PHYSICAL SCIENCE

In the teaching of physical sciences, mainly following types of audio-visual aids are used;

4.6.1 Black Board/Chalk Board/White Board

Chalkboards are the commonest of all visual aids. But the tragedy is that it is rarely used as effectively as it should be. It is one of the simplest and oldest visual teaching aids. Even in the modern age of television, teaching machines, computers etc., it remains as the most trusted and powerful companion of a teacher.

The teacher makes use of the black -board to achieve the following aims :

- Main point for retention.
- Printing facts in mind without cramming.
- Audio-visual aids.
- Helping weak students

4.6.2 Real Objects and Magazines

The real objects are very important in the field of science. On the basis of perception of objects the students get an apparent experience. Objects like rocks, soil, minerals etc. can apparently be shown in the class. To show the object apparently and to make this process more natural the student can be taken for excursions.

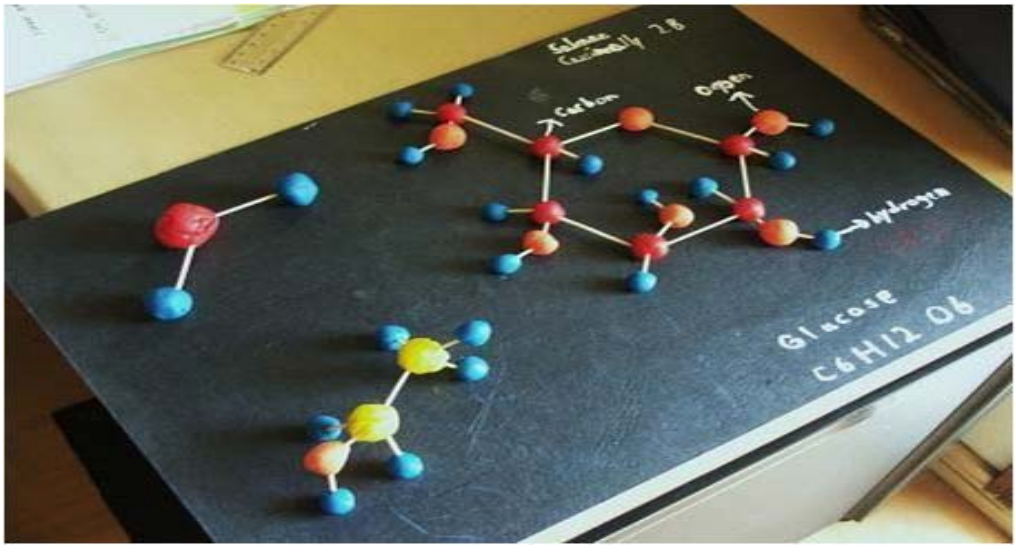
Seeing the object face to face the student get familiarised with these objects. That is why these objects are considered very useful and lively means of teaching.

Magazines

Knowledge of various topics of science can be imparted through the medium of newspapers and magazines by relating these topics to daily life. Facts can be made clear to students by taking examples from the articles published in newspapers and magazines.

4.6.3 Models and Science Kits

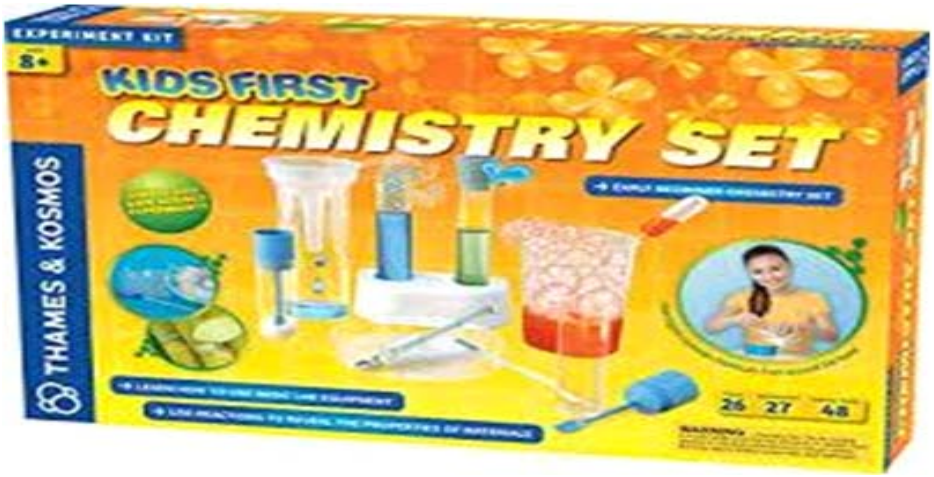
Model is mainly representative or image of any real object. It is a miniature reproduction of the object. Through models, the science teacher can show the interiors of an object which is normally covered or invisible. Models are used a great deal in science teaching. If due to some reason it is not possible to show the real objects to the student in the class then they are shown the models of these objects. These models should bear a close resemblance to the objects so the students perceive a true picture of it.



Science Kits

Science kits is an answer to the new challenges posed by compulsory science teaching, remote single- teacher-village schools, and the problems of science teachers.

Science kits serve the purpose of laboratories. "Science kit is a device of preparing folded apparatus and material and then to arrange them in a box, which may serve as the demonstration table."

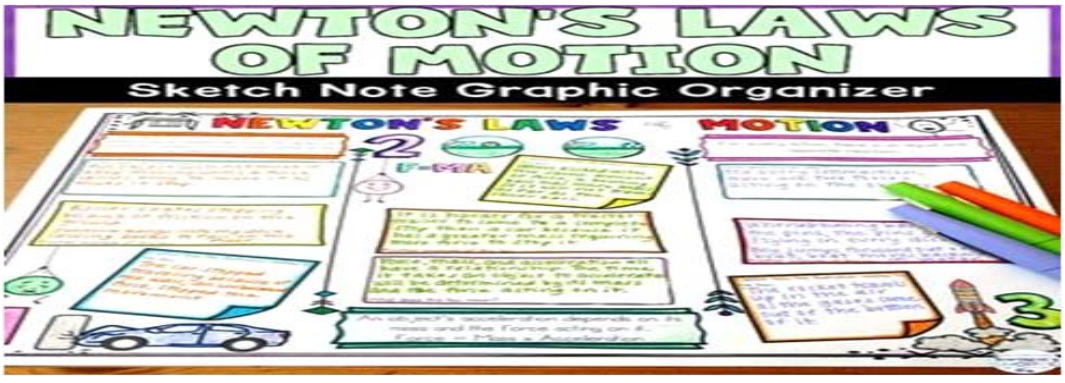


Advantages

- It provides systematic knowledge and understanding of the fundamentals of science.
- It proves opportunities for observations, experimentation, problem solving and investigatory approach.
- It provides opportunities for practical work.
- These are economical & saves time and resources

4.6.4 Charts, Graphs, Maps, Pictures and Diagrams

With the help of the charts, the teacher can explain the various functions, topics and information of science with ease. The advantage of the chart is that the picture which cannot be drawn quickly on the black-board, its charts can be prepared in advance and knowledge can thus be imparted.



The following charts and pictures can be used in the field of physical sciences:-

- Chart depicting various laws and formulae
- Pictures of prominent scientists.
- Pictures related to the developments in physical sciences.
- Charts and pictures depicting the use of science in daily life.
- Structure of atoms and molecules.
- Charts showing different chemical processes.

4.6.5 Projectors

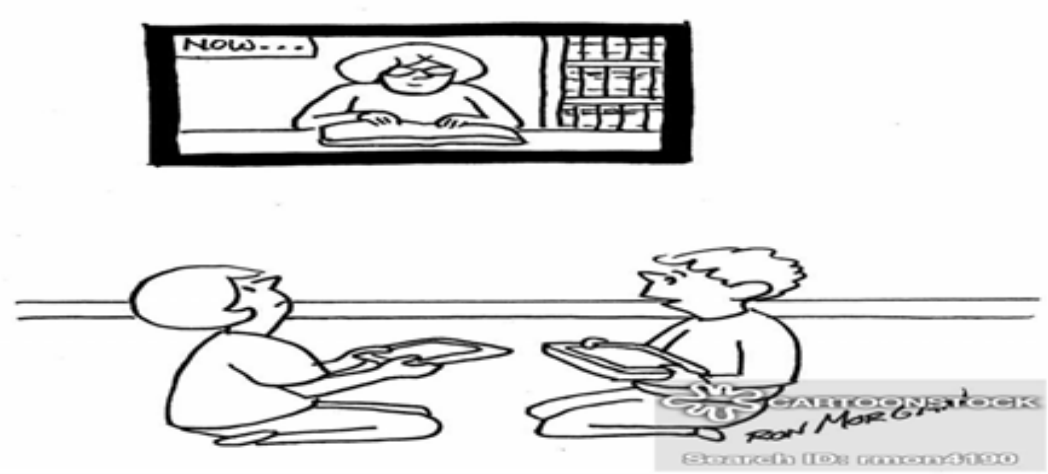
The teacher can show the students slides, film strips and films and make the teaching interesting with the help of a projector. Overhead projector is designed so that the teacher can stay at his seat, near the screen/ wall, face the students and operate the projector himself. He does not need a second man to insert slides in the machine nor he will have run about from the machine to the wall to explain things to the students.

Advantages

- The teacher can face his pupils and at the same time operate the machine.
- The screen is over the head of the teacher and is therefore sufficiently high for the back benchers to see clearly.
- The teacher can point out important features of the pictures by indicating a pencil at the slide.

4.6.6 Television and Radio

It is an invention which combines the features of radio with that of a film. Along with being a good mode of recreation, it is a popular teaching aid in developing countries. Television is gaining so much importance in the field of education that it is being termed as “Electronic blackboard of the future”.



The national channel of Doordarshan (DD1) and the All India Radio are relaying many education related programmes. In these many experiments are conducted, lectures are relayed and his life histories of scientists are highlighted. Teaching by a good teacher and a specialist’s lecture, the student can listen to and watch on the radio and T.V. while sitting at home.

4.6.7 Bulletin Board and Flannel Board

The bulletin board is very useful for giving information and news relating to science topics, exhibiting strange pictures and information about the lesson being taught in the class. Cuttings from various newspapers and magazines etc. can be put up on the bulletin Board.

Flannel board is one of the latest devices effectively used for teaching science. It serves as a very good medium for displaying prepared cuttings. It is very simple to handle and operate. Moreover its cost is very nominal. It is just like a blackboard with a difference that the teacher has not to write or draw anything on it. The figures or pictures to be shown there are cut in advance out of any rough paper, preferably from coloured blotting paper and are stuck to the surface of the board.

In the class, the flannel board is fixed near the black-board. The teacher uses this board for exhibiting the life history of scientists etc. with the help of the paper cuttings etc. When various procedures or its steps are compiled on the board, it becomes an interesting activity for the students. The ideal size of the board is 60X75 cm. The parts to be shown on it should have sandpaper fixed under it because sandpaper sticks on the flannel by slightly pressing it over and can be taken out easily.

Check Your Progress-2

Note: (a) Answer the questions given below.

(b) Compare your answers with those given at the end of this lesson.

1. Model is mainly _____ of any real object.
2. What is the purpose of a science kit?
3. Give one advantage of using charts as AV aid in the classroom.
4. The teacher cannot write or draw anything on the flannel board. (True/False)
5. _____ is also known as “Electronic blackboard of the future”.

4.7 LET US SUM UP

In this module, we have discussed AV aids, their classification and different types of aids used in teaching of physical sciences. Audio means ‘to hear’ and visual stands for

'seeing', so audio visual aids are devices which can be heard or as well as seen. Audio-visual materials are those sensory objects or images which initiate, stimulate and reinforce learning. If AV aids are properly used they help to draw interest; provide First hand experience; develop scientific attitude; inspire correct thinking. teaching aids can be grouped as audio/aural aids, visual aids and audio visual aids; projected and non-projected aids. While Edgar Dale has classified teaching aids by using cone of experience. He emphasised on the fact that learners retain more information "by doing" rather than what they "read", "listen" or "observed". In the teaching of physical sciences, most commonly used audio-visual aids are Chalkboard or Black board, Real Objects, Models, Film strips and films, Charts, graphs and maps, Projectors, Science kits, Television and radio, Computer & teaching machines etc.

4.8 LESSON END EXERCISE

(a) Short Answer Questions

Write short note on following:

1. Define audio-visual aids
2. Uses of audio-visual aids
3. Types of audio-visual aids

(b) Long Answer Questions

1. List the A.V. aids based on classification with an example.
2. Explain any three A.V. aids used for teaching of physical science.

4.9 SUGGESTED FURTHER READINGS

Bruner, J. S. (1966). *Toward a Theory of Instruction*, Harvard University Press, Cambridge, MA, 49.

Dale, E. (1969). *Audio-Visual Methods in Teaching, 3rd ed*. New York: Holt, Rinehart & Winston, 108.

Kohli, V.K. (2006). *How to Teach Science*. Ambala: Vivek Publisher.

Kulshreshtha, S.P. (2005). *Teaching of Science*. Meerut: R.Lall Book Depot.

4.10 ANSWERS TO CHECK YOUR PROGRESS

Answers to Check Your Progress- 1

1. Sensory aids
2. (B)
3. Edgar Dale
4. Overhead projector, Epidiascope

5. (i) It reduces verbalism & eliminates language related problems.

   (ii) It saves time and increases interest.

Answers to Check Your Progress- 2

1. Representative or image
2. Science kit is a device of preparing folded apparatus and material and then to arrange them in a box, which may serve as the demonstration table.
3. The advantage of the chart is that the picture which cannot be drawn quickly on the black-board, its charts can be prepared in advance.
4. True
5. Television

Lesson No. : 5 **Unit : II**

ROLE AND ORGANISATION OF TEACHING AIDS

Structure

5.1 INTRODUCTION

Inclusion of co-curricular activities in the syllabus of school teaching is not a new concept. This is as old as the education itself. These activities give a chance to learners to learn by doing. Such activities help the learners to construct their own knowledge, develop wholesome personality, groom for good citizenship, character building, helps in inculcating civic manners and courtesy. These also help the teacher to generate interest and capture attention of pupils; motivates students for physical and mental activities. A variety of co-curricular activities can be organised by a science teacher like science fair, science club, science trip and science museum etc.

5.2 OBJECTIVES

After going through this lesson, you shall be able to:

- state the importance of science clubs,
- organise a science club,
- explain the concept of field trips,

- develop insight for using community resources for the learning experience and development, and
- develop the skills for preparing improvised apparatus for the science labs.

5.3 FIELD TRIPS

Field trips provide the students an opportunity to bridge the gap between school life and outside life by providing an opportunity to see the practical application of the theories, facts and laws that they learn in the classroom environment.

Objectives of Field Trips

To capitalize educationally the migratory instinct of the child.

The school excursion properly initiated, organised, conducted, completed and evaluated represents an excellent capitalization of his migratory urge.

To acquaint the pupil with his environment. When the pupil visits, post office, historical monuments, science parks he acquires first hand information related to the theoretical framework that is being presented in his schoolbooks.

To interpret, supplement and enrich curricular experiences. Excursions may be undertaken for securing information, changing attitudes, promoting ideals, and enjoying new experiences. They are very good means of getting first hand knowledge, confirming and supplementing theoretical knowledge.

Places of Excursion

A wise teacher will always make use of community resources for the purpose of enrichment, supplementation and correlation of his classwork. Community (rural or urban) offers a large number of opportunities which are of immense value from an educational point of view. For example telephone exchanges, radio stations, science centres. Museums, zoological parks, botanical gardens etc.

Types of Excursion

1. Full day excursion, requiring elaborate transportation, full day planning and additional adult helpers. These longer journeys/trips to historical sites and special events beyond the local community offer valuable opportunities for observation of the environment along the way.
2. Local trips are shorter and more easily planned as visits to factories, radio stations, newspaper plants, wholesale and retail establishments, libraries and the like.
3. Still others are simple like going for nature walks, the journey to the neighbouring farms, or the walk through the parks to gather some needed specimens and to see how nature helps mankind to rejuvenate.

Organisation

There should be following three major steps for the proper organisation of field trips;

Planning

Conducting the Trip

Follow Up Work

Planning - Before an excursion is actually taken up, every pupil as well as the teacher, should be fully aware of just why this particular trip is being planned and how it is related to his own classroom experiences and activities. Children also need to be directed while they are observing. It is always advisable to test the success of the observations while they are still being made. The teacher and pupils may together work out the details and handle the event. A committee may be formed to gather material, formulate questions and increase the interest of the group, not merely in seeing, but in seeing the 'how' and 'why' of the things. The teacher should only be a guide and facilitator. A few sub committees may be appointed by the teacher or selected by the pupils.

Conducting the trip - It is up to the teacher-in-charge to conduct the trip in his best possible way, so that there is no misconduct and all take it as a source of enjoyment and enrichment.

Evaluation- Excursions should be evaluated in terms of the originally established purposes, mistakes and difficulties should be diagnosed, conduct of the group should be discussed, letter of thanks should be written to the persons concerned and highlights of the trip should be recorded in some permanent form for future use.

5.4 SCIENCE CLUBS

In the area of physical sciences, clubs are the most natural means by which the learners get a chance to show suppressed, ignored, hidden and subconscious talents. These clubs develop the spirit of scientific attitude, leadership, co-operation and citizenship.

With the help of these clubs, a number of educational objectives can be achieved. Science Club bridges in-school and out-of-school learning and fosters the development of skills, such as experimentation, critical thinking, and problem solving. By giving our members a supportive environment to explore science, we are also building more confident learners and educators.

Need and Importance of Science Clubs

- Science clubs have great educational value in improving the science of education in schools. As it is enough to acquaint the pupils only with facts and principles of science through classroom teaching.
- Science club links school studies more firmly to the outside world and the students own interest. It provides better opportunities for self-expression.
- The club offers the pupil an opportunity for specialization which he does not have in the classroom. In the classroom his work is formal and involvement is less while in the club the involvement is maximum as the environment is informal and the child constructs his own knowledge through the process of learning.

Aims and Objectives of Science Club

The aims and objectives of a science club may be outlined as below:

- To provide proper incentive and inspiration for the pursuit of scientific knowledge in a rigorous way by broadening their scientific outlook. To make the students understand the value of time and to help them in the proper utilization of their time.
- To provide opportunities for bringing school close to society and to acquaint the people with the services and contribution of science in their daily life.
- To develop among the students the spirit and attitude of healthy competition for the

individual and social cause. To help the students in imbibing the habit of self-reliance, self-dependence and love for manual work

- To inculcate scientific attitude. To provide opportunity for the development of the constructive, explorative & inventive faculties of the students. To develop training in scientific method of problem solving
- To develop students, interest and participation in the practical application of the knowledge related to different branches of science. To create interest in scientific facts and events related to one's surroundings.
- To develop interest in scientific hobbies. To encourage individual and group activities. To stimulate active participation and initiative among students in the learning process.
- To develop creativity and encourage the habit of exploration.
- To create interest in latest inventions and discoveries of science in various fields and to get acquainted with the life history and contributions of great scientists.
- To develop students' interest and participation in the practical application of the knowledge related to different branches of sciences.

Types of Science Clubs

Science clubs can be divided into two groups:

- **The Specialised Interest Clubs;** These include radio club, photographic club, nature study club, agricultural club etc
- **The General Type Clubs**; These include chemistry society, physics association, science club, biology club etc

Organisation

To establish a physical science club, it is important to prescribe objectives, how they will be achieved i.e. methods to achieve the set objectives. The list of the expenditure involved and other job-accomplishments should be given to the head of the institution for the permission and co-operation. Besides the head, all students of science and other students having interest and love for physical science should also be made team mates for co-

operative working. At the time of establishment a meeting should be called, and the objectives, its activities and procedures should be told and its importance highlighted. The constitution of the club should be formulated. The constitution should include the following-

Name of club

Objectives

Scope

Membership

Office-bearers

Treasure

Meeting time and place

Activities

Draft of the constitution of science club- Given below is a draft of the constitution of science club to guide the teacher of science:

Name of institution Physical science club or science club.

Area of work (a) Institution (b) community.

Objectives Besides the objectives given earlier the following objectives can be included:

To prepare community related plans and execute them.

To impart knowledge of new discoveries of science to the community and to explain their importance to them .

To provide leadership to students in the subjects like giving speech; to write technical and scientific descriptions; to keep an account of new publications of science; to publish different bulletins and magazines related to science; to conduct workshops and seminars on problems related to physical science.

Memberships: The teachers should think over as to which students can be members of this club who can cooperate in achieving appropriate objectives.

Office bearers: The office bearers of the club may include Patron, Teacher advisor, Chairman, vice chairman, Secretary, Asstt. Secretary, Treasurer, Editor etc. Under the office bearers act everything like on which post, what type of person, how can be elected and what will be his responsibilities should be clearly written.

Treasury- There should be clear cut instructions as from where the money for the various jobs of the club will be obtained, and how much to be collected from whom, what

type of members will pay (what) memberships fee, where and how the money will be kept.

Meeting of the club and venue: In the constitution it should be clearly mentioned as to who can call a meeting, decide the venue and time of meeting and how many members should be present.

Activities: Mainly the following types of activities can be organised by the club:

Tours/field trips to important sites and worth seeing scientific places like science cities.

Fairs and Exhibitions

Preparation of soaps, Ink, chalks, phenyl, sanitizers etc.

Museum

Celebration of special science days

Lecture of scientists

Preparation of improvised apparatus

To keep the weather - records

- Debate, poster making and essay competitions.
- To have a Bulletin Board and make proper display on it.

For proper management of these activities, a physics circle & chemistry circle should be made. In these circles students having interest and capabilities are made members. Both these circles should undertake different programmes. Each circle has its own chairman, secretary and an executive body of 5-8 members. These circles can work on projects focussing on work improvement and productivity enhancement. These members can give their co-operation in improving the surroundings. These circles can perform the activities like observation competitions, Identification competitions, writing articles competitions, speeches and story writing competitions based on the topics related to physical sciences, Science information competitions, Collection of various types of substances, materials or their pictures, Preparation of science related charts, models, Tour plans, Discussion with specialists, Survey of apparatus of physical sciences etc.

The physical science clubs through their circles, work within the limits of the institution, in a group and for the community than These 'clubs' would be successful in achieving their true meaning. These clubs besides giving knowledge to the students for their daily life, give them self- confidence to choose scientific occupation for their happy and beautiful future. In this manner, these clubs, under the able guidance of capable teachers, with the use of appropriate materials, give the students real training for their future lives.

Check Your Progress-1

Note: (a) Answer the questions given below:

(b) Compare your answers with those given at the end of this lesson

1. List any three types of activities organised by the club.
2. _____ and _____ are the types of clubs.
3. Write any two objectives of organising field trips.
4. Steps involved in organisation of field trip includes _____, _____ and _____.
5. What is the need and importance of establishing science clubs?

5.5 SCIENCE MUSEUM

Science museum means a suitable place in the school campus where different objects and specimens collected from natural or physical environment or constructed and improvised by the students may be placed, preserved and displayed safely and systematically in such a way as to help the students to learn about the related scientific facts and processes through a simple process of observation. The collection of the natural objects of scientific interest in the form of science museums may prove quite effective and beneficial for studying the related scientific facts and processes.

Organisation

Choice of proper accommodation, one has to take care of the following in the selection of suitable sites and places for science museums.

It should be at a reasonable distance from the classes and science laboratories.

The place should be big enough as to accommodate objects and materials related to the different branches of physical and life sciences.

All the articles and objects collected should be kept and demonstrated at quiet safe and sound place, without getting spoiled or damaged, for a long period of time.

The objects should be kept in such a way as to provide a full view from all angles and thus enabling the maximum number of viewers to view the things jointly at a single occasion.

Sources of Articles for Science Museum

Visits and excursions - The student may collect different objects belonging to the physical and social environment during the visits and excursion to the place of scientific interests.

Borrowing - Certain things can be borrowed from the state and district museums, botanical gardens or from the science museums of the neighbouring schools and institutions

Purchases - The charts, models, specimens and real objects should be purchased from the market, factories and other places dealing with the sales of such things.

Improvisation - The charts, models and improvised apparatus etc. may be constructed with the help of students.

Methods of Preservation and Safe Display

Classification - Material collected for the science museum should be placed in a systematic way by putting it in some suitably classified sections either subject wise like chemistry, physics, biology or botany sections or object wise like animals, birds, living and non living objects etc.

Identification - Every article placed in the museum should have its proper identification for being displayed properly. For this purpose we may attach a piece of thick paper or wooden piece by writing on it the following identifying data:

- Name of the object
- Name of the student who has collected the object
- Date on which the object is collected
- A brief description of the object regarding its nature,, characteristics and purpose served etc.

Show cases- All zoological specimens should be kept in the show cases sealed properly, after properly disinfecting them with disinfectants.

Jars- Specimens of different kinds of snakes, lizards and fishes etc. can be kept preserved in the properly sealed jars filled with 30% formalin solution.

Advantages

The science museum has its worth as a valuable aid in the teaching-learning process.

The organisation of the science museum in the school acts as a great source of inspiration for the budding scientists.

The students come across some rare phenomena or objects of scientific interest which are otherwise not seen in normal circumstances.

It helps in creation of genuine interest and developing scientific attitude towards study of science.

5.6 SCIENCE FAIRS

A Science fair is an excellent forum for the display and dissemination of various activities conducted at the Science clubs. It involves - exhibits, lecture-demonstration, presentation of new ideas, techniques, discoveries and projects etc. prepared by science students. It serves as a device for acquainting the parents of the students and people of the locality with the science work that is being done in the school. These fairs are being encouraged by the NCERT through SCERTs all over the country. For this purpose the council has been organising and financing science fairs at district level, state level and national level.

Objectives

According to NCERT, the chief objectives for organising science fairs are given below:

To give impetus and encouragement to the students to try out their ideas and apply their classroom learning into creative channels.

To identify and nurture scientists of India.

To provide a much needed forum for competitive activities of science clubs and individuals.

To bring the people of the area in touch with the school and to meet the teachers and students.

To provide opportunities to students to witness the achievements of their colleagues and thereby to stimulate them to plan their own projects.

To popularise the science activities of the students among all, so that further improvement in standards of performance may be achieved.

To give due encouragement and recognition to the bright and energetic students, who have special science talent.

Exhibits

There should be a large variety of exhibits in a science fair. Some of the important exhibits are given below:

Collection of objects and specimens by the students.

Graphical material such as charts and diagrams etc.

Models- both working and static.

Improvised apparatus

Experiments conducted- both individual and group work.

Investigatory or research type projects.

Other Activities Undertaken in the Science Fairs

A science fair does not consist of an exhibition of some of the above mentioned items only. The opportunity should be utilised to introduce other scientific activities. Here are some suggested activities:

Debates on Scientific topics

Essay competition on Scientific topics

Paper readings

Symposia

Science quiz

Lectures by prominent science teachers

Exhibition of Science Books

Film shows on scientific topics

Organisation of Science Fair

While organising a science fair, following considerations should be kept in mind:

Location of the fair- There should be ample floor area both for the display and movement. Corridor area is as important as the area occupied by the shelves and tables.

The rooms should be well-lighted and so arranged as to provide a smooth flow of traffic.

The location should be well-marked; aisle-spaces, entrances and exits.

There should be provision for electricity supply for artificial lights and power plugs. The available power should be sufficient and the load and plug points well distributed.

There should be suitable arrangements for washrooms and drinking water.

Time consuming exhibits should not be accumulated at one place.

As far as possible, symmetrical furniture arrangements should be provided.

There should be a trained batch of students serving as volunteers to guide people and explain the exhibits.

The place of the fair should preferably be a school building having a large hall and fairly big size class rooms. It will be ideal if such a school is certainly situated, so that more persons may visit the fair.

Steps Involved in the Organisation of Science Fair

1. **Planning-** To start with, the science teacher should seek permission of the head of the institution. Then the support of other teachers and students for organising the fair

should be enlisted. Then an organisation of some teachers and students should be constituted. A meeting of organisation committee should be called to discuss the following aspects:

Theme and sub-theme of the fair.

Objectives

Venue, timing and date

Expenses involved and finances available.

Facilities required

Activities to be conducted

2. **Distribution of Work-** then organising committees should be further divided into small committees and then the members should be allocated with different duties like hospitality and refreshments, stage decoration, seating arrangements and the arrangements of stalls; arrangement of fiances; discipline; formulation of judging criteria; invitation to participants and chief guest etc.

3. **Execution-** Some eminent persons from the field of science should inaugurate the fair. Students, teachers and community members may also be invited to view the fair. There should be separate stalls for various sub-themes. Each model should be properly labeled and accompanied by two or three students to explain its principles and functioning. Other activities like demonstration, skits on scientific themes, debates etc may also be organised.

4. **Judging**- the exhibits on various sub themes should be judged by eminent science experts, judging should on certain criteria such as originality, practical utility, and so on. The judging criteria should be made known to the participants.

5. **Evaluation**-NCERT has given the following criteria for evaluating exhibits

S. No.	Criteria	Marks
1.	Scientific approach	30
2.	Originality	20
3.	Technical skill and workmanship	20
4.	Thoroughness	10
5.	Dramatic value	10
6	Personal interview	10
	Total	100

Science fairs if arranged properly, contribute much to the development of scientific attitude, scientific interests and scientific temper. Science fairs have a vital part in the school curriculum. Interwoven in the texture of the school curriculum they can work wonders for a child's personality and acquaint them with the wide roads of scientific knowledge which leads to success in life.

5.7 PHYSICAL SCIENCE LAB

Laboratory teaching assumes that first-hand experience in observation and manipulation of the materials of science is superior to other methods of developing understanding and appreciation. Laboratory training is also frequently used to develop skills necessary for more advanced study or research. 'Laboratory' word is used for a large room where practical classes are conducted and a group of students carry out practicals. 'Science laboratory' is needed to keep instruments, apparatus, chemicals and other materials safe and secure and ready for use. Various types of apparatus and material are placed in shelves or almirah under lock and key.

The study of physical science is not possible without a laboratory science teacher providing them an opportunity to observe facts and carry out experiments so that their students may obtain proper & complete knowledge of the subject. The students work in the laboratory by themselves, observe, and on the basis of these, they try to deduce conclusions. The environment and the setting of the laboratory should be congenial to encourage students participation. Laboratory helps in the development of a sense of cooperation and spirit of competition.

Objectives of Laboratory

Objective of laboratory are given below:

1. To develop scientific attitude among children through practical work in the laboratory.
2. To develop the skill in handling scientific apparatus instruments & equipment.
3. To provide opportunities for training in scientific methods.
4. To help students in developing the feeling of cooperative resourcefulness initiative, self- dependence, self-confidence. Cohesion, sociability, self-reliance, and self-discipline.
5. To provide real and stable knowledge of science.
6. To provide opportunities to think, observe, apply reasons and to arrive at a decision/ conclusion independently.
7. To encourage students to save the time, resources as well as energy.
8. To arrange an atmosphere which is very conducive for learning science.
9. To enable them to interpret & verify the various principles and substances.

Planning a Science Laboratory

The Govt. of India, committee on plan projects in its report on science Education in secondary schools, emphasizes that the following factors be taken into consideration at the planning stage for the laboratory:-

(a) The number of students working at a time in the laboratory.

(b) The minimum space necessary for every student for comfortable working.

(c) Limitation of number of science teachers in secondary schools.

(d) Need for ancillary accommodation for storage.

(e) Designing the science-classroom and laboratory in such a way that it could be used for science teaching.

(f) Imperative need for the economy.

Organization of Laboratory

For organised teaching of physical sciences, the laboratory should have a preparation room, store room, science room and dark room. In the preparation room of the laboratory such apparatus are collected. Which are to be used in the laboratory or 'science room'. In the room apparatus for daily experiments are kept. The laboratory assistant or the teacher can prepare the experiment in the 'preparation room' In this various apparatus like-nails, rings, screws, glass tubes, jars, ropes, pipes and various tools are kept. In the store room(which is generally inside the laboratory) physical science related apparatus and articles are stored. This room should be kept locked, there should be one door opening in the 'science room' The articles should be properly arranged in large glass almirahs. The various articles should be properly arranged in large glass almirahs.The various articles should be labelled. There should be proper light and ventilation. In the 'science room' the teacher demonstrates the practical/experiment. The seating arrangement in this room should be such, so that all the students can watch the experiment clearly. The seat should be as in theatre i.e'. In ascending order lower in front to higher at the back. There should be proper arrangement of light. The Windows should have dark curtains so that the room can be darkened as and when required. The teacher's label should be big enough to place all the apparatus in front of the students. There should be a black-board at the back or towards the left, which the teacher can use whenever required. There should be pictures of scientists on the walls. The 'dark room' permanently dark but ventilated.

Laboratory for High Schools

There are two types of science labs prevailing at high school level in our country.

1. Lecture-Room/Theatre-cum-laboratory
2. All purpose laboratory.

Lecture-Room/Theatre-Cum Laboratory

Lecture-room/theatre-cum-laboratory plans were originally suggested by Dr. R.H Whitehouse (Formerly principal central Training Institute, Lahore). It combines the laboratory with a classroom where the teacher can carry out his function of imparting education to the students. This is considered to be one of an economical kind of science laboratory, as two functions can be carried out in such a laboratory.

All Purpose Laboratory

This type of laboratory may serve the dual purpose of practical as well as theory work. It is also known as an integrated plan of both physical and life sciences.

5.8 PREPARATION OF LOW- COST TEACHING AIDS IN TEACHING OF PHYSICAL SCIENCE

Low-cost teaching aids are those which require no cost or cheaply available material and developed by locally available resources and expedite the process of learning in the classroom. These apparatus can be prepared out of ordinary items (which people discard as useless) or inexpensive items. Such apparatus which students prepare themselves or with the help of their teachers, which are inexpensive and display some process of science, are called improvised apparatus. In order to prepare such apparatus the teacher should provide proper guidance. Unless the students perform this type of practical activities themselves they will not understand the facts, laws and principles of science and will not have the practical knowledge of the subject and the objectives of teaching of science will not be achieved. Thus it is important that students prepare/improvised apparatus after studying the theory properly according to their interest and ability.

Utility of Improvised Apparatus

Self-improvised apparatus have a number of advantages:

The construction of improvised science apparatus develops a coordination of hand and mind, while gaining knowledge of the practical aspect of science, his interest is created in scientific hobbies and interests.

In assembling these apparatus the items used are of having low cost. Thus, these items are prepared at nominal cost and a science teacher, without burdening the school with extra expenditure prepares the apparatus for experiments and thus makes his school laboratory more enriched and well-equipped.

When children work themselves, they develop interest in scientific activities and apparatus, as a result they attain scientific knowledge and develop scientific outlook.

Self-improvised apparatus have a social utility as the construction of these materials

forms the habit of doing the work by own hands. Loyalty towards labour increases. The habit to work together without any disparity is formed and the child moulds himself according to the needs of the society and moves towards the goal of socialism.

Self-improvised apparatus is prepared under the supervision of the teacher. Thus, the teacher can easily find out which students have scientific potential/talent. The students with such talent can be provided with proper opportunities to explore their hidden talent.

Process of Developing Low Cost Material

The development of improvised apparatus or low cost materials occurs in a sequential manner. The various steps involved in the process are:

Defining the objectives- The objectives of knowledge, skills and attitudes are clearly identified according to the need of the user.

Designing the product- the design of improvised apparatus is developed based on the type of materials used, the cost of production and availability of the resources.

Development of the materials- After designing the apparatus, the material is assembled and developed by the teachers and students with the help of each other.

Pilot testing- The teachers and researchers then test the prepared apparatus. Based on the results, necessary improvements are made in the materials.

Mass production- the materials which successfully pass the pilot testing are finalised for mass production.

Distribution- Adequate number of copies is produced and they are distributed to various schools for academic usage.

Examples of Improvised Apparatus

- A simple burner can be made from a boot polish container. A metal tube may be soldered in the middle on the top of it.
- To prepare a voltmeter, take an used plastic glass. Pierce it with two holes at its bottom. Insert two copper wires in each hole. Fill the glass with acidulated water and invest two test tubes, one on each wire. Connect the wires to the two terminals of a battery, water with begin to decompose into oxygen and hydrogen.
- Improvised solar cooker looks as following;

The following is the list of some other scientific apparatus which may be easily improvised and constructed by the students in the area of physical sciences:

- Hydrometer
- Electric bell
- Spring balance

- A tin can with charcoal burner
- Projector
- Diffusion apparatus

Advantages

- They are freely available, cheap and economical.
- They possess a great educational value.
- It develops creative interest in learners.
- It inspires young students to design, explore and invent new apparatus.
- It provides deeper knowledge of underlying to the students.

Disadvantages

The time and money involved can exceed the limits making it worthless.

Improvised apparatus are not durable

They are crude & are unable to provide accurate results.

Check Your Progress-2

Note: (a) Answer the questions given below.

(b) Compare your answers with those given at the end of this lesson.

1. Name two activities undertaken in the science fairs.
2. Write two chief objectives for organising science fairs given by NCERT.
3. Science museum means a suitable place in the school campus where different objects and specimens are collected from the natural or physical environment. (True/False)
4. Types of science labs include
   A. Lecture-Room-cum-laboratory
   B. All purpose laboratory
   C. Lecture Theatre-Cum-laboratory.
   D. All of the above
5. _____ require no cost or cheaply available material and developed by locally available resources and expedite the process of learning in the class room.

5.9 LET US SUM UP

In this module, we have discussed various organizations (field trips, science clubs, science fairs, physical science labs) having important role in teaching physical science.

Science clubs are the most natural means by which students get a chance to show suppressed and unconscious talents. These clubs develop the spirit of scientific leadership, co-operation and citizenship.

Field trips help to bridge the gap between school life and outside life by providing an opportunity to see the practical application of the theories, facts and laws that they learn in the classroom environment. Steps involved in the organisation of a field trip are planning, conducting the trip and follow up.

Science museum means a suitable place in the school campus where different objects and specimens collected from a natural or physical environment or constructed and improvised by the students may be placed, preserved and displayed safely and systematically.

Science fairs act as a device for acquainting the students, parents and people of the locality, with the science work that is being done in the school. Such fairs are conducted at district level, state level and national level. Activities involved in science fairs are debate on Scientific topics; Essay competition on Scientific topics; Paper readings; Science quiz.

Physical science lab provides an opportunity to observe facts and carry out experiments so that students may obtain proper & complete knowledge of the subject.

Low-cost teaching aids are of great importance in teaching science as it is always not possible to buy costly apparatus for providing a clear idea about that particular object or process. Therefore, improvised apparatus is of great relevance as it can be prepared out of ordinary items (which people discard as useless) or inexpensive items and also develops the habit of doing the work by own hands.

5.10 LESSON END EXERCISE

Short Answer Questions

Explain the need and importance of science clubs.

Describe the objectives of science clubs

How do science museums act as a source of teaching science?

List the activities involved in the science fair.

Discuss the importance of the physical science laboratory in teaching science.

What do you mean by improvised apparatus?

Long Answer Questions

Explain the organisation of science clubs.

Explain the steps involved in organisation of field trips.

Discuss the types of science laboratories at high school level.

Explain the steps involved in organisation of science fairs.

Discuss the utility of improvised apparatus and the procedure to develop improvised apparatus.

How can science museums contribute to science learning?

5.11 SUGGESTED FURTHER READING

Behrendt, M., & Franklin, T. (2014). A Review of Research on School Field Trips and Their Value in Education. *International Journal of Environmental & Science Education 9,* 235-245. Doi: 10.12973/ijese.2014.213a

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5.12 ANSWERS TO CHECK YOUR PROGRESS

Answers to Check Your Progress-1

1. Celebration of special science days; Lecture of scientists; science fairs and exhibition
2. The Specialised Interest Clubs; The General Type Club
3. (i) To capitalize educationally the migratory instinct of the child

   (ii) The school excursion properly initiated, organised, conducted, completed and evaluated represents an excellent capitalization of his migratory urge.
4. Planning; Conducting The Trip; Follow Up Work
5. (i) Science club links school studies more firmly to the outside world and the students own interest. It provides better opportunities for self-expression.

   (ii) The club offers the pupil an opportunity for specialization which he does

not have in the classroom. In the classroom his work is formal while in the club is informal.

Answers to Check Your Progress-2

1. Debated on Scientific topics; Essay competition on Scientific topics
2. (i) To give impetus and encouragement to the students to try out their ideas and ` apply their classroom learning into creative channels.

   (ii) To identify and nurture scientists of India.
3. True
4. D
5. Improvised Apparatus

———————

TECHNIQUES OF TEACHING PHYSICAL SCIENCE

Structure

6.1 INTRODUCTION

If Science is done badly, it is worse than useless. Science taught badly, not only degenerates into superstition, but makes a negative contribution to education. To learn Science is to do Science. There is no other way of learning Science.

Dr. D.S. Kothari

In this modern age the psychological viewpoint tells us that study of any object cannot be successful and complete unless it is based on the age, characteristics and needs of the child. Thus in the field of science, teaching methods determine either teacher keeping in mind the capability of students and the curriculum. Thus with the help of these methods the teacher imparts understanding of subject matter along with the knowledge of curriculum.

"In the absence of the correct directions/ true path, a person can't reach his destination, in the same way, in the absence of proper method, the student cannot be given correct knowledge."

Therefore, while selecting the teaching techniques, a teacher of physical science should take care of following points:

The assistance of method in achieving the objectives of teaching of physical science.

Teachers should have complete knowledge of that particular selected method.

Availability of material required for the particular selected method.

Experimental nature of method.

Methods selected should be according to the age and capability of students.

Method should cater the needs of individual differences.

The methods used for teaching of physical sciences are given below:

- Lecture cum demonstration method
- Project method
- Problem solving method
- Inductive deductive method
- Heuristic method

6.2 OBJECTIVES

After going through this lesson, you shall be able to:

- describe various methods of teaching physical science,
- differentiate between the methods used in teaching physical science, and
- discuss the merits and demerits of a particular method.

6.3 LECTURE-CUM-DEMONSTRATION METHOD

The main drawback with the lecture method is that it is a one-sided process. The teacher talks too much and the students are totally neglected. The best method is that which involves a kind of ebb and flow between the teacher and the taught, where the teacher and children are really a part of an educative process.

The lecture and demonstration methods are interrelated. Thus, both these methods combine to give rise to the lecture cum demonstration method. In this method the faults of the lecture method are removed and combined with the merits of the demonstration method, thus making this method more impressive. This combined method is economical both time and energy wise. In this method the teacher explains the theoretical portion with the help of a lecture method making use of diagrams and statements. Then to make the theoretical portion more clear, he performs the experiment with the help of students.

During the course of experimentation he keeps asking questions from the students. This method should be used keeping in mind the age, capability and surroundings of the students.

Lecture-cum-Demonstration Method

Steps

1. Planning and preparation

While preparing for a lesson, the teacher must bear in mind the following points:

(a) Subject matter;

(b) Lesson notes including the type of questions to be asked;

(c) Rehearsal of experiments;

(d) Collection and arrangement of apparatus required.

The teacher must be fully conversant with the topic concerned. Drawing up a lesson plan is equally necessary and this should include a list of the principles to be explained, a list of the experiments to be demonstrated and the type of questions to be put to the students, in an order to be followed, in the class. This will make his work very systematic.

2. Introducing the lesson

The lesson should be introduced in a problematic manner so that the students can appreciate and realize the importance of the topic in hand. The teacher should begin the lesson with some personal experience or incident, a simple and interesting experiment , a familiar anecdote or by telling a story. Not to speak of the start, it should be the constant enthusiasm of the teacher to maintain interest and enthusiasm of the pupils.

3. Presentation of the Subject-matter:

(a) **Broader sense of teaching:** Teaching should be kept on as broad a basis as possible.

The teacher must introduce into his teaching material and illustrations from a wide field of knowledge and experience.

(b) **Use of illustrations:** A well informed teacher must draw illustrations from all branches of science despite the fact that the lesson deals only with a particular branch of science.

(c) **Judicious questions**: The questions should be so arranged that their answers form a complete teaching unit. Questions may not bring forth the required answer, but it is enough if they have been able to create a desire in a student to know what he does not now.

(d) **Pronunciation of the teacher:** In the delivery of a lesson the voice of the teacher plays a vital role. The teacher should speak slowly, deliberately and with correct pronunciation. Bombastic and ambiguous terms should be avoided. He should pose as if he is narrating some interesting experience in a very homely way and should give a feeling of friendliness to the students.

4. Performance of experiments

The work at the demonstration table should be a model for the students to copy. The main points about experimentation are as follows:

(a) Clear results: The experiments work and their results should be clear and striking.

(b) Simple Experiments: Experiments should be simple and speedy.

(c) Appropriate time of experiments: Experiments should be well spaced throughout the lesson.

(d) Convincing experiments: One big, convincing and striking experiment is of more value than half a dozen experiments, not closely related to the topic.

(e) Arrangement of apparatus: Apparatus should be arranged in an order in which the experiments are to be shown.

5. Chalk-board Work

Chalk board is mainly used for two purposes:

For writing important results and principles in summarized form. For drawing necessary sketches and diagrams. We should be careful regarding below mentioned points:

(a) The writing on the chalkboard should be neat, clean and legible.

(b) Always start from the left hand corner; do not begin a second line until the first line has extended across the chalk-board.

(c) Over-writing or 'scribing' should never be resorted to. There should be proper spacing between different letters.

(d) Single lined diagrams should be preferred over double lined diagrams.

(e) Every part of the diagram must be labelled properly. While labelling a diagram let all the letters be horizontal and draw lines to the various items on the diagram.

(f) Chalk-board may conveniently be divided into two parts, and the right hand side be reserved for sketches and diagrams.

6. Copying and Supervision

The demonstration lesson will remain incomplete if the students do not copy the chalk-board summary and the sketches drawn on the board. The teacher must supervise the students while copying from the board in order to keep a check on the mistakes made by the students.

Merits

This method is psychological because the students have not to imagine anything, instead they are shown concrete things and living specimens. Therefore, they take active interest in the teaching-learning process.

This is a very suitable method when the apparatus is very costly or very sensitive and is likely to be damaged if handled by the students.

It is useful in case of dangerous experiments like preparation of chlorine.

This method is considered most economical. When apparatus is not sufficient for the students to do practicals individually, the teacher may perform the experiment before the whole class. Also it saves time when a number of experiments can be performed in a short time.

Although it is not a child centered method, yet the students are kept engaged in various activities like observing, taking notes, answering questions, drawing diagrams etc.

This method is suitable for all types of students i.e. average, below average and above-average. There is uniformity of teaching and all learn at a common place.

Demerits

The desirable laboratory skills are developed among the students.

This method does not cater to the individual differences. As slow learners and the genius are made to crawl at the same pace.

This is not a child centered method. The pupils are not the active participants in the process. The teacher has the final responsibility to perform the experiments.

6.4 PROJECT METHOD

According to Kilpatrick, "A project is a whole-hearted purposeful activity proceeding in a social environment."

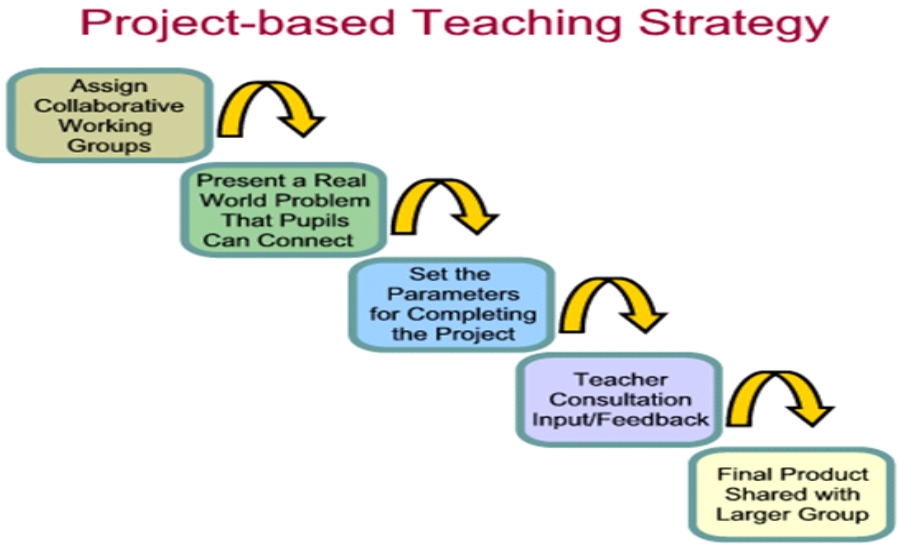
According to Stevenson, "A project is a problematic act carried to completion in its natural setting."

This method, as devised by Kilpatrick, was given a perfect shape by Stevenson. In this method a problem is posed to the students and they find a solution for it. The students work according to his interest and willingness.

Principles - This method is based on following principles:

1. Principle of purposiveness
2. Principle of activity
3. Principle of reality
4. Principle of utility
5. Principle of freedom
6. Principle of social development.

For planning and administering each project, these principles are stressed upon.



Steps of Project Method

1. **Selection of a project**- The teacher should create such circumstances that the students start formulating projects. The teacher and the students should discuss these projects independently. As far as possible the student should get a chance to formulate a project. The teacher should give the necessary suggestions.

2. **Prepare an outline**- After the selection of the project a programme should be prepared for the completion of the project. The students should be give full freedom to discuss the project among themselves. After an outline has been chalked out, the students should be given various responsibilities according to their capabilities and all this should be noted down.

3. **Execution of programme-** After the outline of the programme has been prepared, work should start accordingly. The responsibilities which have been given to the students. They start working on them. The students have to acquire various types of knowledge to complete their responsibilities. The knowledge thus attained is more permanent. The teacher encourages the students, supervises their work and makes changes if required.

4. **Evaluating-** After the project is completed the teacher and students together evaluate it . Based on the objectives of the project, its success or failure is discussed. The students discuss their work and rectify their mistakes and recollect useful knowledge.

In Physical Sciences various types of projects can be prepared and the students can get practical knowledge. For example, cleanliness of the school campus, beautification of science room, arranging science fairs, improvising apparatus, establishment of a science museum etc.

Merits of Project Method

The students contemplate, study and work.

The students remain active throughout the execution of the project.

The students have to perform mental and physical work thus they develop the values of dignity of labour.

The students realise their responsibilities and shoulders it.

They develop qualities of patience, contentment and satisfaction.

This is a psychological method.

This is based on 'learning by doing'

Relationships are developed among various subjects.

The acquired knowledge is permanent.

Demerits

Knowledge is not acquired in a sequential manner.

It is difficult to complete the syllabus by this method.

Teachers have to put in more labour.

It takes more time.

Check Your Progress-1

Note: (a) Answer the questions given below:

(b) Compare your answers with those given at the end of this lesson

1.The method of using both demonstration and lectures in an integrated way.

A. Lecture-cum-demonstration

B. Lecture method

C. Demonstration method

D. Heuristic method

2. The project method is very time consuming and syllabus cannot be completed in a systematic and sequential manner. (True/False)

3. The right sequence of steps involved in project method are

1. Execution of programme
2. Selection of project
3. Evaluation
4. Prepare an outline

Options-

A. 1, 4, 2, 3

B. 2, 4, 1, 3

C. 2, 1, 4, 3

D. 1, 2, 4, 3

4. The project method was devised by _____

5. Which of the following methods should be used by the teacher when the apparatus is very costly or very sensitive and is likely to be damaged if handled by the students.

A. Project method

B. Problem solving

C. Lecture cum demonstration

D. Heuristic method

6.5 PROBLEM SOLVING METHOD

"Problem solving in teaching refers to the task making decisions or doing things that learners wants to make or to do, the nature of which he is able to understand but for which at the time he has no solution" **Hammonds Carsie**

Problem solving may be defined as a process of raising a problem in the minds of students in such a way as to stimulate purposeful, reflective thinking in arriving at a rational solution.

According to Ausubel, Problem solving involves concept formation and discovery learning.

In this method, the problem should be placed in front of the students in clear words and should be according to the understanding experiences of the students. The student does the analysis synthesis of the problem with the help of the teacher and tries to find the solution. This method or approach, when applied properly in the classroom or science laboratory will help in the development of scientific attitude and training in scientific method.

Procedure - This method has following steps:

1. **Identification of the problem** - The first step in Problem solving should be identification of a problem. Thereafter, it has to be specifically stated or defined. The problem selected should be according to the needs and level of the students.
2. **Collection of relevant data** - After the problem has been precisely stated, the next step is collection of data. It is to be collected from all sources- from library books, observations etc. while collecting data, students should be careful about mechanical errors (caused by instruments) and personal errors.
3. **Formulation of hypothesis** - After defining the problem and collecting the relevant data, the next important stage is to formulate some tentative hypothesis. A hypothesis is probable for the problem in hand. There can be a number of predictive or tentative solutions for a problem. Therefore a student of science should design his hypotheses quite objectively on the basis of facts or information he has gathered in the form of data.
4. **Prediction of other observable phenomena** - After the formulation of hypotheses the prediction of other observable phenomena can be derived from the hypotheses.

This step is an extension to the last one because here the implications of the hypothesis are drawn.

5. **Observation of predicted phenomena** - The next significant step is to make more observations and to conduct experiments. The experiment will show the occurrence and non-occurrence of the predicted phenomena. It will prove or reject those predictions.

6. **Drawing conclusions** - The last step is to accept, reject or modify the given hypothesis and draw conclusions out of that.

Merits

Problem solving method is considered to be an excellent method owing to following advantages:

Problem solving develops many skills of identifying a problem, formulating hypotheses, conducting an experiment and coming to conclusions which are very useful for future life.

This method is based on an important principle of psychology i.e learning by doing.

This method imparts training in scientific method i.e "the method of the scientists"

It develops a scientific attitude among the students by making them truthful and honest; for they learn to arrive at their own decision after collecting data and experimentation.

Through this method students become self dependent and Learn by their own planning and administration.

Through this method ,students develop a habit of diligence.

Since the students carry out all their work themselves at their own pace, the teacher has no worry about assigning or checking the home-task.

It makes the student self-dependent, self-reliant and self confident.

Here the teacher gives individual attention since students may be performing different experiments.

The knowledge gained through this method is retained for a much longer time since they learn by self-activity.

Limitations

This Method suffers from numerous drawbacks or limitations, which are as under:

It is a long and slow process and makes it impracticable for prescribed syllabus to be covered within a specific period.

Through this method, the teacher lays stress on experimentation at the cost of other important aspects of science teaching.

Here, too much stress is laid on practical work and students form a wrong idea of nature science. They began to believe that science is something to be done in a laboratory. forgetting that laboratories are made for science and not science for laboratories.

It pre-supposes that all the students are problem solvers or discoverers which is not possible. Only a few of them with creative faculties may be interesting in problem solving.

6.6 INDUCTIVE DEDUCTIVE METHOD

Inductive method or induction is a procedure to prove a universal law by showing that if it is true in a particular case, it is also true in other similar cases. In this method, we proceed from concrete to abstract, from a specific example to universal law or from particular to general.

Stages

There are four stages in this method

Specific example

Supervision

Generalisation

Evaluation

It is a very suitable method for teaching science since all the conclusions or principles are the result of inductions.

Example - Effect of Acid on Litmus -

Add blue litmus solution in hydrochloric acid, it is turned red.

Add blue litmus solution in sulphuric acids, it is turned red.

Add blue litmus solution in nitric acid, it is turned red.

These three particular cases lead us to generalise that all acids turn blue litmus red.

Merits

It is scientific method and helps to develop scientific mindedness

It also helps to develop scientific attitude

It develops critical thinking and a habit of keen observation.

This method is logical as well as psychological.

There is ample scope for activities of the pupils.

The children develops genuine interest since they move from known to unknown.

It develops self confidence and self reliance.

It develops the habit of intelligent hard work.

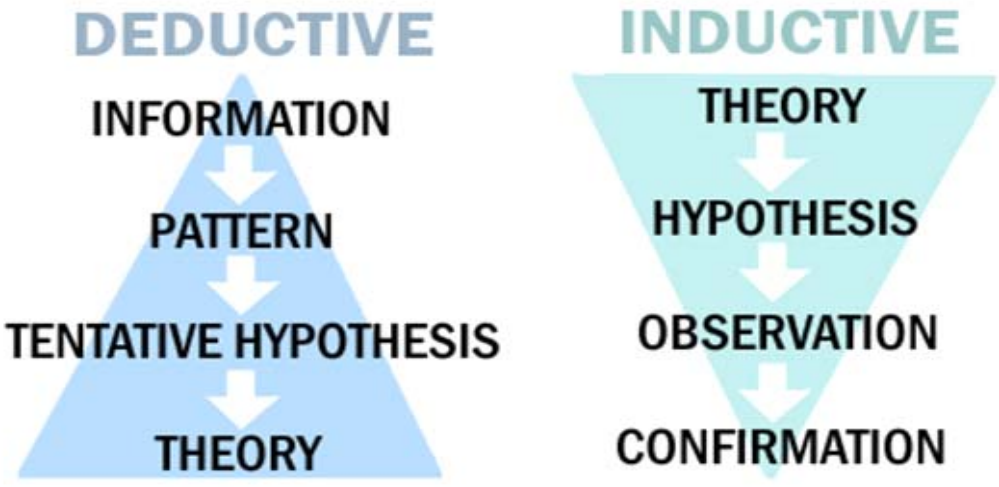
Demerits

Inductive logic is not absolutely conclusive. In certain cases it develops probability to some extent, which increases with the amount of data available.

It is a lengthy and time consuming method.

This method can be considered complete and perfect if the conclusions are verified through a deductive method.

It is not possible to apply this method in solving and understanding all the topics of science.



“Deduction is the reverse of induction. Hence the facts are deducted or analysed by the applications of established formulas or experimentation. Here the approach is confirmatory and not explanatory.”

Thus in this method, the students proceed from general to particular, from unknown to known, from abstract to concrete or from established principles to their applications.

Example - All acids contain hydrogen. It can be confirmed by reacting different acids, one by one, with a particular metal and then verifying with the help of other metals.
Example - Water is H2O. It can be confirmed by the electrolysis of acidified water, using a water voltmeter.

Merits

It is a very suitable method for lower classes since they are provided with established principles.

In this method, the teacher feels happy and secure since his work is simplified.

He only gives the scientific principle and the students are asked to apply it in certain situations.

It is a speedy process and our length syllabi can be easily covered.

It supplements induction and thus helps to complete the process of induction-deduction .

Limitations

It does not help to develop scientific attitudes.

It does not impart training in scientific methods.

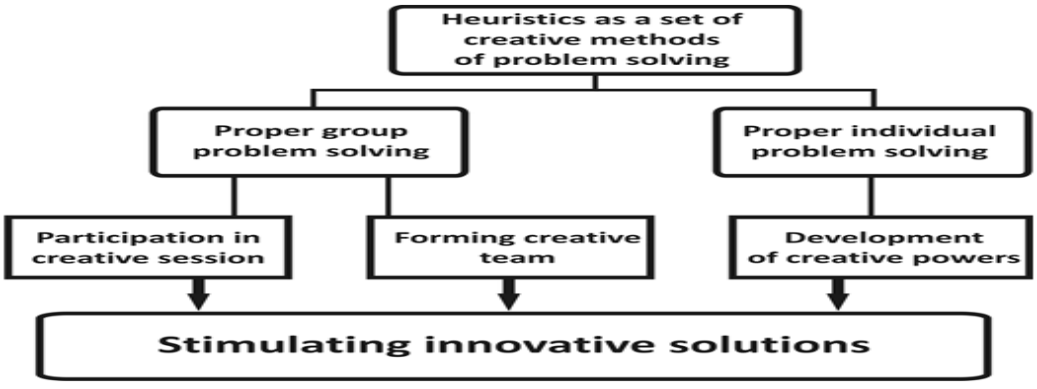
It encourages rote memory.

It is unscientific in the sense that the approach is confirmatory and not explanatory.

6.7 HEURISTIC METHOD

The term 'Heuristic' has been derived from a greek word 'heurisko' meaning to find out or discover.

According to Prof. Armstrong, "Heuristic methods of teaching are methods which involve our placing of students as far as possible in the position of the discoverer-methods which involve their finding out instead of being merely told about things."



In this method, the students learn by exploring. The teacher's role is that of the path setter who rectifies the faults at the proper time. As the children work and perform experiments they attain new knowledge. This method requires that the pupil should approach his scientific studies from the position and in the spirit of a research worker, for science is not a subject to be talked about. It is a practical subject and the correct way of learning is by doing. Prof. Armstrong believed in doing and not in observing what was being done.

Procedure

Each student is given a sheet of instructions and is required to perform the experiments concerning the problem in hand. He should follow the instructions and do everything himself. But there are situations when even a little guidance from the teacher can do a lot of good. Regarding selection of the problem, it must be suggested by pupils themselves, as far as possible. As students can't take interest if the problems are imposed.

Merits

The students develop a scientific temper.

This method makes them exact and brings them closer to truth.

The students observation power is developed and his thinking ability is enhanced.

The student develops interest and capability to work harder.

The students develop qualities of activeness, self-confidence and self-dependence.

This method prepares students for life.

The knowledge obtained is more stable.

Contemplation and awakening increase in the students.

The whole work is completed in the class so there is no need for home work.

Demerits

The pace being slow, the whole curriculum cannot be completed in a fixed time period.

The students find it difficult to draw conclusions.

The teacher has to make special preparations for this method.

This method is not applicable for junior classes.

For this method a good laboratory and a good library are required.

More money is spent.

Difficult to impart education to larger groups.

Check Your Progress-2

Note: (a) Answer the questions given below.

(b) Compare your answers with those given at the end of this lesson.

1. Heuristic means
   A. To show
   B. To find out
   C. To do
   D. To act
2. Armstrong was the exponent of
   A. Problem solving method
   B. Project method
   C. Heuristic method
   D. Discussion method
3. We move from specific to general in
   A. Inductive method
   B. Deductive method
   C. Drill method
   D. Discussion method
4. Which is the THIRD step in the problem solving method?
   (a) Identification of problem
   (b) Recognition and definition of problem
   (c) Conclusion
   (d) Formulation of hypothesis
5. Problem solving method provide the students an opportunity to solve problems scientific steps. (True/False)

6.8 LET US SUM UP

In this module, we have discussed about various methods used for teaching of physical sciences along with their merits and demerits i.e.

In the lecture cum demonstration method, the teacher explains the theoretical portion with the help of a lecture method making use of diagrams and statements. Then to make the theoretical portion more clear, he performs the experiment

with the help of students. It includes the steps named as Planning and preparation of a lesson, Introducing the lesson, Presentation of the Subject-matter, Performance of experiments, Chalk-board Work,

Copying and Supervision.

In the project method, a problem is posed to the students and the students work according to his interest and willingness in order to find a solution for it. Such methods help in providing practical knowledge to the students. Steps included in this method are Selection of a project, Prepare an outline, Execution of programme, Evaluation of the project.

In Problem solving method, the problem should be placed in front of the students in clear words and should be according to the understanding experiences of the students. The student does the analysis synthesis of the problem with the help of the teacher and tries to find the solution. This method or approach, when applied properly in the classroom or science laboratory will help in the development of scientific attitude and training in scientific method. It includes the following steps Identification of the problem, Collection of relevant data, Formulation of hypothesis, Prediction of other observable phenomena, Observation of predicted phenomena, drawing conclusions.

In the Inductive method, we proceed from concrete to abstract, from a specific example to universal law or from particular to general. It focuses on four stages i.e. providing specific examples; Supervision; Generalisation; Evaluation while in deductive method, the students proceed from general to particular, from unknown to known, from abstract to concrete or from established principles to their applications.

In heuristic method, the students learn by exploring. The teacher's role is that of the path setter who rectifies the faults at the proper time. As the children work and perform experiments they attain new knowledge.

Therefore, while selecting the teaching techniques, a teacher of physical science should take care about objectives of a particular topic; material required; and age and capability of students.

6.9 LESSON END EXERCISE

Short Answer Questions

Write short note on the following:

Inductive method

Deductive method

Heuristic method

Long Answer Questions

Explain lecture cum demonstration method along with its merits and demerits.

Describe problem solving method and its procedure.

Explain the project method in teaching science.

6.10 SUGGESTED FURTHER READING

Kohli, V.K. (2006). *How to Teach Science*. Vivek Publishers: Ambala.

Kulshreshtha, S.P. (2005). *Teaching of Science*. Meerut: R.Lall Book Depot.

Mangel, S.K. (1995). *Teaching of Physical and Life Science*. Delhi: Arya Book Depot.

Sharma, R.C., & Shukla, C.S. (2002). *Modern Science Teaching*. New Delhi: Dhanpat Rai Publishing Company Ltd.

Yadav, M.S. (2004). *Teaching of Science*. New Delhi: Anmol Publications, Pvt. Ltd.

Zaidi, S.M. (2004). *Modern Teaching of Science*. New Delhi: Anmol Publications Pvt. Ltd.

6.11 ANSWERS TO CHECK YOUR PROGRESS

Answers to Check Your Progress-1

1. (A)
2. True
3. (B)
4. Kilpatrick
5. (C)

Answers to Check Your Progress-2

1. (B)
2. (C)
3. (A)
4. (D)
5. True

EVALUATION : MEANING AND PURPOSE OF EVALUATION

Structure

7.1 INTRODUCTION

Evaluation is a wider term and plays a very important role in teaching learning process. Assessment of student's learning require the use of a number of techniques for measuring students achievement. But assessment is more than collection of techniques. It begins with the identification of goals and end with the judgement concerning the extent to which goals have been attained.

The secondary education commission observed," nevertheless examination and especially external examinations have proper place in any scheme of education". External

examination have simulated effect both on the pupils and teachers by providing well defined goals and objective standard of evaluation.

In the last decades evaluation has became more and more of an independent science, that has its roots in many disciplines and turns out to be a useful tool for understanding and implementing policy studies, performance assessment, engineering design, investment portfolio and so on. In this cheptor we will discuss evaluation.

7.2 OBJECTIVES

After going through this lesson, you shall be able to:

- describe about the history and concept of evaluation,
- state the steps of evaluation,
- explain the various uses and purpose of the evaluation, and
- enlist the principles on which evaluation is based.

7.3 HISTORY OF EVALUATION

- **Chester W. Harris (1960)** traces the history of the concept of the evaluation to the thirties of the twentieth century. It emerged as a "reaction against the relatively narrow information – and skill – centered educational measurement of the previous decade". A strong movement developed under the leadership of Alvin c. EU rich, Ralph Tyler and Waynewright stone to broaden the various area of appraisal - attitude, interest, idea, way of thinking, work habit and personal and social responsibility.
- **The American council on education** made in large scale cooperative effects to improve evaluation procedures in the post war era.
- **Tyler's** contribution was his insistence of defining the goals and objective in behavioral term and making them the basis of instrument developing in education and evaluation.
- **In india,** the work related to evaluation began in the 1960's.

7.4 MEANING OF EVALUATION

Evaluation is a systematic process of determining the progress of a child and extent to which the educational objectives are achieved by pupils."

Evaluation forms an integral part of the total system of education. It is intimately

related to educational objectives. It is essential in the never-ending cycle of formulating goals, measuring progress towards goals and determining the new goals.

Evaluation is "a systematic process of collecting and analyzing data in order to determine whether, and to what degree, objectives have been, or are being, achieved (Gay, 1991)". It leads to decision making.

It determines the modificationof the child's behavior to an extent to which they change. It measures that how effective are the "learning experiences."

A simple representation explaining the role of evaluation in the teaching-learning process is shown below:

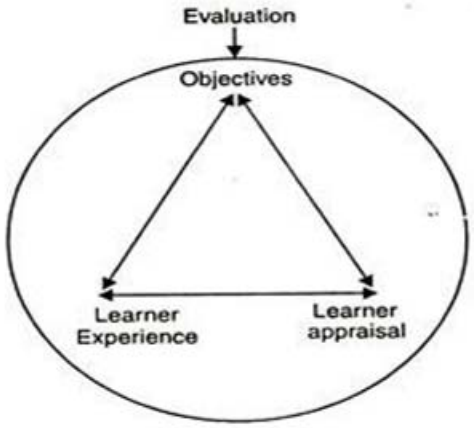


Fig. 7.1 Representation of the Role of Evaluation in the Teaching-Learning Process

Some of the definitions of the evaluation will prove helpful in understand the meaning:

"The process of determining to what extent the educational objectives are actually being realized"(Tyler, 1950)

*"Evaluation is the process of determining merit, worth, or significance; an evaluation is a product of that process"***(Scriven, 1991)**

According to Hanna, "The process of gathering and interpreted evidence changes in the behavior of all students as they progress through school is called evaluation".

Muffat says, "Evaluation is a continuous process and is concerned with than the formal academic achievement of pupils. It is interpreted in the development of the individual in terms of desirable behavioral change relation of his feeling, thinking, and actions".

Goods defines, "Evaluation is a process of judging the value or something by certain appraisal."

According to James M. Bradfield, "Evaluation is the assignment of sym-bols to phenomenon, in order to characterize the worth or value of a phenomenon, usually with reference to some cultural or scientific standards"

According to Thorndike and Hagan, "The term evaluation is closely re-lated to measurement. It is in some respect, inclusive in-cluding informal and intuitive judgement of pupil's progress. Evaluation is describing something in term of selected attributes and judging the degree of acceptability or suitability of that which has been described.**"**

According to Norman E. Gronlund and Robert L. Linn, "Evaluation is a systematic process of collecting, analyzing and interpreting in-formation to determine the extent to which pupil's are achievement instructional objectives".

According to C.V. Good, "The process of ascertaining or judging the value or amount of something by use of a standard of standard of appraisal includes judgement in terms of internal evidence and external criteria. From the above definitions it can b said that evaluations a much more comprehensive and inclusive term than the measurement and test. A test is a set of question measurement is assigning numbers to the results of test according to some specific rules on the other hand evaluation adds value judgment.

On the basis of above-mentioned definition of evaluation, you can construct your own definition, such as;

It is more comprehensive than mere in-clusive than the term Measurement. It goes ahead of measurement which simply indicates the numerical value. It gives the value judgement to the numerical value. It includes both tangible and intangible qualities.

According to Bebey (1977), evaluation as "the systematic collection and interpretation of evidence leading as a part of process to a judgment of value with a view of action". If you analyze this definition, you can identify four key elements of evaluation as follows:

- Systematic collection of evidence
- Its interpretation

- Judgment of value
- A view of action

Let us try to understand the above terms used.

Systematic collection implies that whatever information is gathered, should be acquired in a systematic and planned way with some degree of precision.

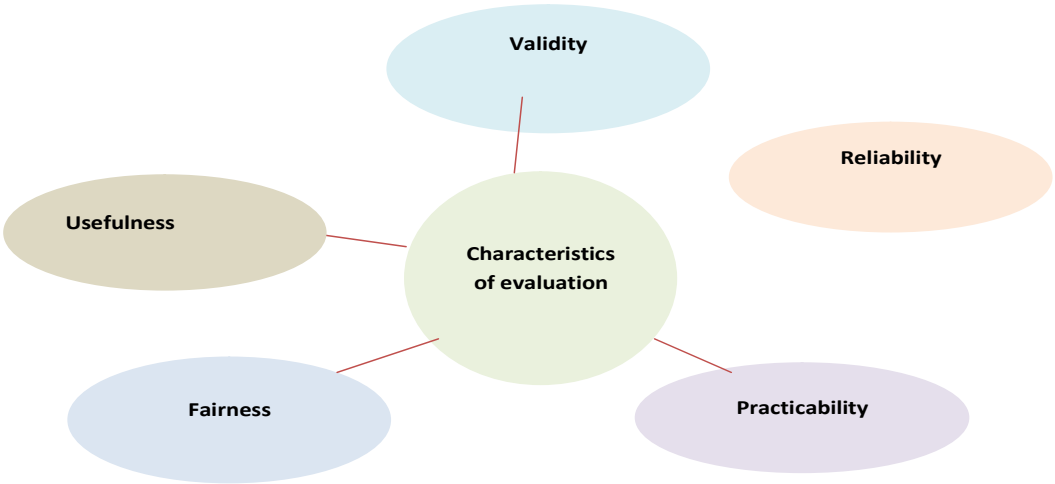
Information gathered systematically should be carefully analyzed and interpreted; superficial observations may lead to wrong interpretation.

Judgment of value takes evaluation far behind the level of mere description of what is happening, but requires judgments about the worth of an endeavor.

A view of action means every decision has a specific reference to action. It may be conclusion oriented or decision oriented.

Elements/ Characteristics of Evaluation As a teacher whenever you are involved in the evaluation process, you should ensure that evaluation should have following characteristics, which are often termed as "elements of a good evaluation".

Let us discuss each characteristic for our clear understanding:Validity



Evaluation in Teaching- Learning Process

Validity: A valid evaluation is one which actually tests what is set out to test i.e., one which actually measures the behavior described by the objective (s), under scrutiny.

Reliability: It is a measure of consistency with which the question, test or examination produces the same result under different but comparable conditions. A reliable evaluation mechanism is independent of the characteristics of individual evaluator.

Practicability: Evaluation procedure should be realistic, practical and efficient in terms of their cost, time taken and ease of application.

Fairness: Evaluation must be fair for all learners. This can be possible by accurate reflecting of range of expected behaviors as desired by the course objectives.

Usefulness: Evaluation should be useful for all learners. Feedback from evaluation must be made available to learners and help them to prove their current strengths and weaknesses.

1. **E-** Ethically Conducted
2. **V -**Values Diverse Opinions
3. **A -** Accurate and Technically Adequate Information
4. **L -**Leads to Continuous Learning and Improvement
5. **U**-Uses Participatory Methods
6. **A-**Affordable/Appropriate in Terms of Budget
7. **T -**Technical Persons Carry it Out/Timely Carried Out
8. **I -**Indicators properly selected and Studied
9. **O -**Opens opportunity for better understanding developmental changes
10. **N -**Never Used for Fixing Blames and Finding Faults

Ethically Conducted:

Every evaluation practice should be conducted ethically and the evaluators must recognise the participants' entitlement to privacy. Evaluators should ensure that data is kept securely and that no publication will directly or indirectly lead to a breach of agreed confidentiality or anonymity. Evaluators shall respect people's right to provide information in confidence and make participants aware of the scope and limits of confidentiality

Values Diverse Opinions:

The evaluator should include the opinions and ideas of all the stakeholders in his/her evaluation report.

Accurate and Technically Adequate Information on the Merit of Program (Being Assessed) is Provided:

Evaluator can also use the evaluation report to share his suggestions or even suggest alternatives. He/She should be able to reflect differences between alternatives and to distinguish the relative degree of impact across the alternatives.

Leads to Continuously Learning and Continuous Improvement:

The evaluation report should be easily understandable and provide enough information so that informed decisions can be made on its basis. The evaluation must be such that all the stakeholders should be able to interpret the evaluation criteria and its findings. When communicated rightly, any mistakes previously done will not be repeated in the future and will pave way for efficiency, learning and improvement. The evaluation practice should extract lessons learned during the project and communicate them to the concerned authorities to improve upon them

Uses Participatory Methods:

Participatory evaluation ensures that the evaluation focuses on locally relevant questions that meet the needs of project planners and beneficiaries. Participatory approaches also allow the stakeholders to determine the most important evaluation questions that will affect and improve the ongoing/ended project works

Affordable/Appropriate in terms of Budget:

The evaluation conducted or to be conducted should be efficient in the use of resources. Evaluation should be intelligently designed and executed.

Timely Carried Out:

Nearly every evaluation is time bound. Either it has to be carried out **in a specific time**or**at a certain time.** Some project requires its evaluation to be conducted soon after the project is finished and some require after some time.

Indicators Properly Selected and Studied:

The evaluator should properly select the indicators so that his findings are in line with the outcomes of the project. Moreover, the evaluator must evaluate all the indicators and its results in the context of the project, the project area and the project beneficiaries.

Never Used for Fixing Blames& Finding Faults:

As stated in the start, evaluation must be conducted ethically, with no intention of harming someone or supporting someone unethical.

Some more characteristics are:

Continuous process: -Evaluation is a continuous process. It leads together with Teaching-learning process.

Comprehensive: -Evaluation is comprehensive as it includes everything can be evaluated.

Child-Centered: -Evaluation is a child-centered process which gives importance to the learning process, not to the teaching process.

Remedial: -Evaluation comments on the result which helps in remedial work it is not a remedy. Evaluation is remedial in nature.

Cooperative process: -Evaluation is a cooperative process involving students, teachers parents, and peer-groups.

Teaching Methods: -Effectiveness of teaching methods is evaluation.

Common practice: -evaluation is a common practice among the proper growth of the child mentally and physically.

Multiple Aspects: -it is concerned with the total personality of students.

Check Your Progress-1

Note: (a) Answer the questions given below.

(b) Compare your answers with those given at the end of this lesson.

1. Gives reinforcement and feedback to teacher, students and the teaching learning processes.
2. _____helps the child in selecting the right electives.

3. Which approaches allow the stakeholders to determine the most important evaluation questions that will affect and improve the ongoing/ended project works?

4. In which year the work related to evaluation began in India?

5. Evaluation gives the value Judgement to the numerical value. (true / false)

6. Every evaluation practice should be conducted ethically. (true / false)

7. Every evaluation is time bound. (true / false)

8. Evaluation comments on the result which helps in _____it is not a remedy.

7.5 STEPS INVOLVED IN EVALUATION

The steps of evaluation process correspond with the steps of teaching-learning process. Like in teaching-learning process, in evaluation process also we consider the objectives to be achieved; methods and tools to be used to collect, record, compile evidence of achievements of objectives; and we try to determine the outcomes i.e. what all objectives and goals have been achieved. Briefly, these steps are described in this section.

(1) Identification and Definition of Objective

It is desirable to have instructional objectives for any educational programme, course, and learning experience etc. The instructional objectives provide directions not only in planning and implementation but also in measuring the progress. The objectives are worked out by the entire faculty at the institutional level based on the philosophy of the educational programme, level of preparation of students, health care delivery system, societal needs and expectations etc. These objectives are further defined more specifically in terms of actual behaviors that are observable and measurable by individual teacher at the instructional level. Consideration is given to the maturity level of students, competencies which need to be developed, the duration of the experience and adequacy of the situations under which experiences are given. You need to refer these units and recapitulate. For the evaluation to be effective and consistent all those who are involved in the process of evaluation must have clear cut understanding of objectives defined in terms of observable student's behavior.

(2) Identification of Situations

The next step in the process of evaluation is to identify or arrange situation in which students get opportunity to display the specific behavior to be evaluated. The situation

which we select must be able to evoke the behaviors and the presence or absence of these can be observed. For example, one of the objectives of midwifery nursing is that "students are able to give complete antenatal care". Such an event can occur in antenatal clinic in the hospital, health Centre and in the home. The students need to be placed in these areas where they can give evidence of their performance.

(3) Selecting and Devising Evaluating Tools and techniques

The tools and techniques are the means of collecting evidence about students' progress (knowledge, attitudes and skills) in desired direction. There are varieties of techniques and tools which can be used to assess students learning in theory and skill performance and building up of attitude in nursing. These include variety of achievement tests for testing knowledge such as essay type test, short answer tests, objective tests, observational techniques and tools for evaluating skill performance and attitudes such as observational check lists, rating scales, anecdotal record, critical incident record etc. These tools are selected and devised by the teachers and administered in variety of situations in unbiased manner to get reliable and valid measure of students' achievements/performance.

Now a days standardized tools are also available which can be used by the teachers. Thus, the tools which are identified and devised must be tested for validity, reliability, objectivity and usability. These are briefly discussed in next section.

(4) Making Decisionson Ways of recording, Scoring, rating or describing Behavior and the Basis of Collecting Evidence.

Appropriate mean/criteria for recording information so that it will be comparable. Recording forms for term papers, project assignments, case presentation and various kinds of tests are needed to be developed. Methods of scoring of information received in test situations must be developed. This involves distribution of scores to different areas of learning according to the relative importance, setting of criteria for scoring, scoring key etc.

(5) Administration of Evaluating Tools-and Techniques and Their Appraisals

The tools and techniques that are selected and devised/ developed are administered and their validity, reliability and usability are checked. Favorable environmental conditions need to be established to permit students to give their best performance.

(6) Developing Methods of Interpretation and Feedback

All the evidence of student's performance gathered through variety of evaluation techniques and tools (tests, observations, interviews etc.) should be compiled together to determine students' progress and learning outcomes. This will provide feedback to students about their achievements and accordingly actions can be taken to improve. This will also provide feedback to the teachers and authority about the effectiveness of teaching learning process and the educational programme, the difficulties encountered and accordingly remedial measures can be taken by teachers as well as be the authority.

7.6 IMPORTANCE OF EVALUATION IN EDUCATION

Evaluation is done to fulfill the following needs and Importance:

1. (a) It helps a teacher to know his pupils in details. Today, education is child-centered. So, child's abilities, interest, aptitude, attitude etc., are to be properly studied so as to arrange instruction accordingly.

(b) It helps the teacher to determine, evaluate and refine his instructional techniques.

(c) It helps him in setting, refining and clarifying the objectives.

(d) It helps him to know the entry behaviour of the students.

2. It helps an administrator.

(a) In educational planning and

(b) In educational decisions on selections, classification and placement.

3. Education is a complex process. Thus, there is a great need of continuous evaluation of its processes and products. It helps to design better educational programmes.

4. The parents are eager to know about the educational progress of their children and evaluation alone can assess the pupils' progress from time to time.

5. A sound choice of objectives depends on an accurate information regarding pupil's abilities, interest, attitude and personality traits and such information is obtained through evaluation.

6. Evaluation helps us to know whether the instructional objectives have been achieved or not. As such evaluation helps planning of better strategies for education.

7. A sound programme of evaluation clarifies the aims of education and it helps us to know whether aims and objectives are attainable or not. As such, it helps in reformulation of aims and objectives.

8. Evaluation studies the 'total child' and thus helps us to undertake special instructional programmes like enrichment programme, for the bright and remedial programmes for the backward.

9. It helps a student in encouraging good study habits, in increasing motivation and in developing abilities and skills, in knowing the results of progress and in getting appropriate feedback.

10. It helps us to undertake appropriate guidance services.

From the above discussions it is quite evident that evaluation is quite essential for promoting pupil growth. It is equally helpful lo parents, teachers, administrators and students.

7.7 PRINCIPLES OF EVALUATION

1. **Selection of tools: -**when aim of evaluation is clear before us then, preparation of appropriate tool is necessary to achieve them.
2. **Use of tools:** -tools should be used for completion of objectives. Different tools are used to achieve different objectives.
3. **Variety of tools:** -for evaluation purpose single tool is not useful and doesn't serves the purpose so variety of tools are needed.
4. **Merits and demerits of Tools:** -evaluator should have knowledge of tools of evaluation. He should keep in mind their merits and demerits.
5. **Work and Ethics:** -evaluator should work very diligently while evaluating and should keep in mind, the principles and ethics of evaluation.

7.8 FUNCTIONS OF EVALUATION

1. Evaluation helps in preparing instructional objec-tives:

Learning outcomes expected from class-room discussion can be fixed by using evaluation results.

What type of knowledge and understanding the student should develop?

What skill they should display?

What interest and attitude they should develop?

Can only be possible when we shall identify the instructional objectives and state them clearly in terms of intended learning outcomes. Only a good evaluation process helps us to fix up a set of perfect instructional objectives.

2. Evaluation process helps in assessing the learner's needs:

In the teaching learning process, it is very much necessary to know the needs of the learners. The instructor must know the knowledge and skills to be mastered by the students. Evaluation helps to know whether the students possess required knowledge and skills to proceed with the instruction.

3. Evaluation help in providing feed back to the stu-dents:

An evaluation process helps the teacher to know the learn-ing difficulties of the students. It helps to bring about an im-provement in different school practices. It also ensures an ap-propriate follow-up service.

4. Evaluation helps in preparing programmed materials:

Programmed instruction is a continuous series of learning sequences. First the instructional material is presented in a limited amount then a test is given to response the instructional material. Next feedback is provided on the basis of correctness of response made. So that without an effective evaluation process the programmed learning is not possible.

5. Evaluation helps in curriculum development:

Cur-riculum development is an important aspect of the instructional process. Evaluation data enable the curriculum development, to determine the effectiveness of new procedures, identify areas where revision is needed. Evaluation also helps to determine the degree to what extent an existing curriculum is effective. Thus, evaluation data are helpful in constructing the new curriculum and evaluating the existing curriculum.

6. Evaluation helps in reporting pupil's progress to parents:

A systematic evaluation procedure provides an objective and comprehensive picture

of each pupil's progress. This com-prehensive nature of the evaluation process helps the teacher to report on the total development of the pupil to the parents. This type of objective information about the pupil provides the foun-dation for the most effective co-operation between the parents and teachers.

7. Evaluation data are very much useful in guidance and counselling:

Evaluation procedures are very much neces-sary for educational, vocational and personal guidance. In order to assist the pupils to solve their problems in the educational, vocational and personal fields the counsellor must have an objec-tive knowledge of the pupil's abilities, interests, attitudes and other personal characteristics. An effective evaluation procedure helps in getting a comprehensive picture of the pupil which leads to effective guidance and of counselling.

8. Evaluation helps in effective school administration:

Evaluation data helps the administrators to judge the extent to which the objectives of the school are being achieved, to find out strengths and weaknesses of the curriculum and arranging special school programmes. It also helps in decisions concerning admis-sion, grouping and promotion of the students.

9. Evaluation data are helpful in school research:

In order to make the school programme more effective, researches are necessary. Evaluation data help in research areas like comparative study of different curricula, effectiveness of different methods, effectiveness of different organisational plans, etc.

7.9 USES OF EVALUATION

(i) Teaching:

Evaluation is concerned with assessing the effectiveness of teaching, teaching strategies, methods and techniques. It provides feedback to the teachers about their teaching and the learners about their learning.

(ii) Curriculum:

The improvement in courses/curricula, texts and teaching materials is brought about with the help of evaluation.

(iii) Society:

Evaluation provides accountability to society in terms of the demands and requirements of the employment market.

(iv) Parents:

Evaluation mainly manifests itself in a perceived need for regular reporting to parents. In brief, evaluation is a very important requirement for the education system. It fulfils various purposes in systems of education like quality control in education, selection/entrance to a higher grade or tertiary level.

It also helps one to take decisions about success in specific future activities and provides guidance to further studies and occupation. Some of the educationists view evaluation virtually synonymous with that of learner appraisal, but evaluation has an expanded role.It plays an effective role in questioning or challenging the objectives

7.10 PURPOSE OF EVALUATION

Evaluation serves a number of purposes in education, Some of the well-known. purposes are to grade, rank, classify, compare and promote the students, It is also used for certifying the completion of a course, selection of students for admission or scholarship, and for predicting their future success in different endeavors. However these are the purposes of end-of- the term evaluation, The basic purpose of evaluation has been to bring about quality improvement in education which it does by providing feedback regarding pupil learning, classroom teaching, appropriacy of curriculum and course content, It also helps bring about all round development of the students' personality when it is used for developing their non-cognitive capacities.

Improvement of Learning

Evaluation of pupil progress contributes directly to improvement in pupil learning. This is done in a number of ways.

Evaluation procedures used help clarify for the pupil what it is that the teacher wishes him/her to learn. Feedback from evaluation provides him/her with concrete information about his/her progress. It also indicates his/her readiness for future learning activities. Through this continuous evaluation, the teacher knows the extent of learning at every stage. If there are any hard spots or gaps of learning, appropriate remediation can be provided. For students, who slow good progress, enrichment measures can be initiated.

Thus, evaluation helps in improving learning through diagnosis and remediation. It enables the teacher to keep a continuous and regular watch on pupil development,

It is only evaluation of learning which motivates the students to learn. If there is no evaluation in the classroom, perhaps the students would not study at all. Evaluation also promotes a healthy competitive spirit in children and stimulates thein to show their excellence.

Besides, there are other uses of evaluation results which have relevance for parents., Through the results. the parents can know the weak and strong points related to the learning of their children. If the evaluation is being done in a comprehensive manner, the teacher can also report on the overall personality growth of the child to the parent. This will develop a better co-operation between the teacher and parents for the progress of the child. Parents can take remedial measures in case of any particular deficiency.

Improvement in Teaching

Evaluation can also promote the accountability of the teachers. The children's results can tell whether the poor performance of the students is due to poor teaching, defective methodology or due to absenteeism of teachers or callousness in teaching. Thus, evaluation can work as an important instrument for improvement in teaching.

Professional development of the teachers is almost-directly related to the feedback through evaluation. A teacher earns a reputation on the basis of the result shown by the pupils whom she has taught. If the students do not show desirable learning outcomes, then she may have to think of changing his/her strategies of teaching, improving the instructional material, updating his/her knowledge or going for a refresher course, thereby exploring new approaches. These steps will automatically help his/her professional development

Renewal of Curriculum or Course Content

Evaluation also gives information regarding the effectiveness of the course content. There may be certain curricular areas which may prove to be difficult for the students as their maturity level is not developed enough to cope up with them. This fact can be identified through evaluation and its feedback. If it is found out consistently by the feedback of the evaluation of different pupils that a particular curricular area is not suitable for them, it may be modified. Such information is useful in judging the appropriateness of the pre-

determined objectives, of the course as well. Hence, evaluation can provide a basis for curriculum revision.

Development of Non-Cognitive Capacities. In today's world the development of intellectual powers is not enough. The development of social intelligence, emotional intelligence and physical aspects of personality is also as vital as the development of mental intelligence. The prime concern of education is tobring about an all-round development of human personality which can bedone by developingnon-cognitive capacities of students along with the cognitive-capacities. This can be ensured only when a school takes up the system of evaluating these aspects of children's personality. The comprehensive evaluation takes into cognizance the learning outcomes of both the scholastic and non-scholastic domains of human personality. The areas included in the non-scholastic domain are the social-personal qualities, interests, attitudes, values and physical growth of the students which need to be developed and evaluated consciously in the context of present-day educational system.

The evaluation of non-scholastic areas in the Indian condition, as observed by Agrawal (1998) not only brings to light the hidden qualities in children, but also prepares them for the future. There are certain traits, qualities, attitudes and values which are needed. by an individual for success in life. For example, qualities of regularity, punctuality, discipline, initiative, industriousness and cooperation are valued in professional life; qualities of respect for others, truthfulness, emotional stability are required for a happy personal life.

Another reason why it is important for teachers to know about the students' attitudes, interests, values and general make up is that this knowledge can be used to remove their learning difficulties and enhance their academic achievement, quite frequently the learning difficulties of students are related to their personality (Edward, 1997). They are influenced by the student's attitudes, values and interests. If a teacher knowsSachin likes sports, she might have him read sports magazines in order to help improve his reading.Thus. teachers can capitalize on the interests and attitudes of their pupils. (Mehrens and Lehmann, 1987)

Check Your Progress-2

Note: (a) Answer the questions given below.

(b) Compare your answers with those given at the end of this lesson.

1. Evaluation is concerned with assessing the effectiveness of _____strategies.

2. Evaluation is a_____ and comprehensive process.

3. What is the third step involved in the evaluation process?

4. Evaluation helps to provide data for _____.

5. A planned evaluation helps a teacher in deciding and developing the _____,,_____and _____of teaching.

6. The teacher observes and measures the changes in the _____of his pupils through testing.

7. Evaluation tools should be used for completion of _____.

8. Which is the next step in evaluation after setting up the objectives?

7.11 LET US SUM UP

1. Evaluation is the process of gathering and interpreted evidence changes in the behavior of all students as they progress through school.

2. Evaluation is a cooperative process involving students, teachers, parents, and peer-groups.

3. Evaluation helps to clarify the objectives of education. The objective of education is to change in learner's behavior. By evaluation, a teacher can prove of change to learner's behavior.

4. The secondary education commission observe," nevertheless examination and especially external examinations have proper place in any scheme of education. External examination has simulated effect both on the pupils and teachers by providing well defined goals and objective standard of evaluation.

7.12 LESSON END EXERCISE

1. Define Evaluation in your own words.

2. Explain the process of evaluation

3. Discuss any five uses of evaluation

4. Enlist the purposes of evaluation,

7.13 SUGGESTED FURTHER READINGS

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7.14 ANSWERS TO CHECK YOUR PROGRESS

Answers to Check Your Progress - 1

1. Development functions.
2. Predictive functions.
3. Participatory approach
4. 1960
5. True
6. False
7. True.
8. Remedial work.

Answers to Check Your Progress - 2

1. Teaching
2. Continuous
3. Selecting Teaching Points
4. Research Generalization
5. Ways, Methods, Techniques
6. Behavior
7. Objectives
8. Decide the content to help in the realization of objectives.

Lesson No. : 8 **Unit : III**

TYPES OF EVALUATION

Structure

8.1 INTRODUCTION

Many types of evaluation exist, consequently evaluation methods need to be customised according to what is being evaluated and the purpose of the evaluation. It is important to understand the different types of evaluation that can be conducted over a program's life-cycle and when they should be used. The main types of evaluation are process, impact, outcome and summative evaluation.

Before you are able to measure the effectiveness of your project, you need to determine if the project is being run as intended and if it is reaching the intended audience. It is futile to try and determine how effective your program is if you are not certain of the objective, structure, programming and audience of the project. This is why process evaluation should be done prior to any other type of evaluation.

8.2 OBJECTIVES

After going through this lesson, you shall be able to:

- explain the meaning of evaluation,
- expound the types of evaluation based on different characteristics, and
- describe the functions and characteristics of various types of evaluation.

8.3 MEANING OF EVALUATION

The term evaluation is closely re-lated to measurement. It is in some respect, inclusive in-cluding informal and intuitive judgement of pupil's progress. Evaluation is describing something in term of selected attributes and judging the degree of acceptability or suitability of that which has been described.

8.4 TYPES OF EVALUATION

There are many different types of evaluation. Each type has its own set of processes and/or principles. Sometimes the list can seem a bit overwhelming, especially for those new to monitoring and evaluation (M&E). This unit categorises and explains the key features of common types of evaluation. The categorisation is based on five criteria (Action Aid (2016), based on IFRC (2011)). The criteria are:

• the purpose of the evaluation;

• who conducts the evaluation;

• when the evaluation is carried out;

• the general approach used; and

• cross-cutting themes.

Evaluation can be classified into different categories in many ways.

Some important classifications are as follows:

8.4.1 Placement Evaluation:

Placement evaluation is designed to place the right person in the right place. It ensures the entry performance of the pupil. The future success of the instructional process depends on the success of placement evaluation.

Placement evaluation aims at evaluating the pupil's entry behaviour in a sequence of instruction. In other words, the main goal of such evaluation is to determine the level or position of the child in the instructional sequence.

We have a planned scheme of instruction for classroom which is supposed to bring a change in pupil's behaviour in an orderly manner. Then we prepare or place the students for planned instruction for their better prospects.

When a pupil is to undertake a new instruction, it is essential to know the answer of the following questions:

a. Does the pupil possess required knowledge and skills for the instruction?

b. Whether the pupil has already mastered some of the instructional objectives or not?

c. Whether the mode of instruction is suitable to pupil's interests, work habits and personal characteristics?

We get the answer to all the probable questions by using a variety of tests, self -report inventories, observational techniques, case study, attitude test and achievement tests.

Sometimes past experiences, which inspire for present learning also lead to the further placement in a better position or admission. This type of evaluation is helpful for admission of pupils into a new course of instruction.

Examples:

i. Aptitude test

ii. Self-reporting inventories

iii. Observational techniques

iv. Medical entrance exam.

v. Engineering or Agriculture entrance exam.

8.4.2 Formative Evaluation:

(also known as 'evaluability assessment')

Formative evaluation is used to monitor the learning progress of students during the period of instruction. Its main objective is to provide continuous feedback to both teacher and student concerning learning successes and failures while instruction is in process.

Feedback to students provides reinforcement of successful learning and identifies the specific learning errors that need correction. Feedback to teacher provides information for modifying instruction and for prescribing group and individual remedial work.

This type of evaluation is used to monitor the progress made during the instruction process. It helps in making decisions relating to the development of learner or courses.

- the purpose of the evaluation;
- who conducts the evaluation;
- when the evaluation is carried out;
- the general approach used; and
- cross-cutting themes.

Evaluation can be classified into different categories in many ways.

Some important classifications are as follows:

Types of Evaluation

According to function	According to approaches	According to nature of reference/interpretation
1-Placement 2-Formative 3-Diagnostic 4-Summative	1-Formative 2-Summative	1-Norm-referenced 2-Criterion-referenced

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This type of evaluation is used to monitor the progress made during the instruction process. It helps in making decisions relating to the development of learner or courses. It provides feedback at appropriate stage of the teaching- learning process which helps in making changes in the curriculum, teaching strategies and the learning environment.

Thus, it aims at improvement of instruction. Formative evaluation also provides feedback to pupils. The pupil knows his learning progress from time to time. Thus, formative evaluation motivates the pupils for better learning. As such, it helps the teacher to take appropriate remedial measures.

"The idea of generating information to be used for revising or improving educational practices is the core concept of formative evaluation."

It is concerned with the process of development of learning. In the sense, evaluation

is concerned not only with the appraisal of the achievement but also with its improvement. Education is a continuous process.

Therefore, evaluation and development must go hand in hand. The evaluation has to take place in every possible situation or activity and throughout the period of formal education of a pupil.

Cronback is the first educationist, who gave the best argument for formative evaluation. According to him, the greatest service evaluation can perform is to identify aspects of the course where education is desirable. Thus, this type of evaluation is an essential tool to provide feedback to the learners for improvement of their self-learning and to the teachers for improvement of their methodologies of teaching, nature of instructional materials, etc.

It is a positive evaluation because of its attempt to create desirable learning goals and tools for achieving such goals. Formative evaluation is generally concerned with the internal agent of evaluation, like participation of the learner in the learning process.

8.4.2.1 The functions of formative evaluation are:

(a) Diagnosing:

Diagnosing is concerned with determining the most appropriate method or instructional materials conducive to learning.

(b) Placement:

Placement is concerned with the finding out the position of an individual in the curriculum from which he has to start learning.

(c) Monitoring:

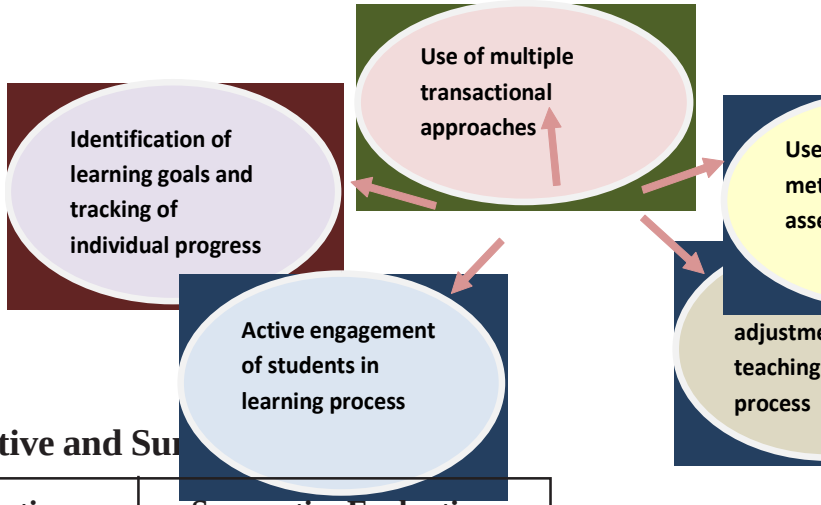
Monitoring is concerned with keeping track of the day-to- day progress of the learners and to point out changes necessary in the methods of teaching, instructional strategies, etc.

8.4.2.2 Salient Features of Formative Evaluation Are As Follows:

- ❖ It builds on the prior knowledge, and experiences of the learners, and ensures learner friendly assessment.
- ❖ It helps in enhancing the learning abilities of the learner.
- ❖ It provides scope for the use of variety of activities, and various tools and techniques for promoting holistic development of the learners.
- ❖ It ensures learning in a non-threatening and supportive environment.
- ❖ It provides descriptive feedback to children for realising their strengths and weaknesses.

- ❖ It provides a chance to the learners to reflect on their performance, as it realises the role of motivation and self-esteem of students learning.
- ❖ It encourages learners to understand the criteria/parameters that have been used to judge their performance.
- ❖ It helps learners to actively and continuously engage in learning.
- ❖ It provides feedback to the teachers to use teaching strategies according to the needs of the learners.
- ❖ It is diagnostic and remedial, formal and informal approach of assessment

Components of formative evaluation



Examples of formative evaluation:

i. Monthly tests.

ii. Class tests.

iii. Periodical assessment.

iv. Teacher's observation, etc.

Distinction Between Formative and Su

Parameters	Formative Evaluation	Summative Evaluation
Time of use	During the process of instruction	At the end term/semester or session
Purpose	To know the progress and mastery of learning. To provide feedback both to the learners and teachers. To provide data for summative evaluation	To certify and grade the learners. To provide feedback to the learners for further study. It includes formative evaluation.

Parameters	Formative Evaluation	Summative Evaluation
Learning Objectives	Are related with the topic caught. Are related in scope.	Are related with the objectives of the course and the programmes. Are vast in nature.
Process	By classroom observation. Can be conducted through oral/ written teacher made tests. By conducting peer and group assessment. Mostly internal in nature. It supports criterian-referenced evaluation. Formative evaluation is usually a quick evaluation.	By conducting term end examination. Mostly external in nature. By conducting mostly written type of examinations. By using teacher-made as well as standardized tests. It supports norm-referenced evaluation. Output of formative evaluation can be used in summative evaluation.
Tools and techniques used	By using varieties of assessment tools and techniques like text, questionnaire, scale, schedule, quiz etc.	Can only be conducted through written test, paper and pencil etc.

8.4.3 Diagnostic Evaluation

It is concerned with identifying the learning difficulties or weakness of pupils during instruction. It tries to locate or discover the specific area of weakness of a pupil in a given course of instruction and also tries to provide remedial measure.

N.E. Gronlund says "…… formative evaluation provides first-aid treatment for simple learning problems whereas diagnostic evaluation searches for the underlying causes of those problems that do not respond to first-aid treatment."

When the teacher finds that inspite of the use of various alternative methods, techniques and corrective prescriptions the child still faces learning difficulties, he takes recourse to a detailed diagnosis through specifically designed tests called 'diagnostic tests.

Diagnosis can be made by employing observational techniques, too. In case of necessity the services of psychological and medical specialists can be utilised for diagnosing serious learning handicaps.

8.4.4 Summative Evaluation

It is concerned with making judgements about a finished product or process. Terminal examinations whether external or internal are good examples of it. Various forms of summative evaluation are like cumulative assessments, teacher made achievement tests, rating of laboratory skills and evaluation of projects.

Summative evaluation is done at the end of a course of instruction to know to what extent the objectives previously fixed have been accomplished. In other words, it is the evaluation of pupils' achievement at the end of a course.

The main objective of the summative evaluation is to assign grades to the pupils. It indicates the degree to which the students have mastered the course content. It helps to judge the appropriateness of instructional objectives. Summative evaluation is generally the work of standardized tests.

It tries to compare one course with another. The approaches of summative evaluation imply some sort of final comparison of one item or criteria against another. It has the danger of making negative effects.

This evaluation may brand a student as a failed candidate, and thus causes frustration and setback in the learning process of the candidate, which is an example of the negative effect.

The traditional examinations are generally summative evaluation tools. Tests for formative evaluation are given at regular and frequent intervals during a course; whereas tests for summative evaluation are given at the end of a course or at the end of a fairly long period (say, a semester).

8.4.4.1 The functions of this type of evaluation are:

(a) Crediting:

Crediting is concerned with collecting evidence that a learner. has achieved some instructional goals in contents in respect to a defined curricular programme.

(b) Certifying:

Certifying is concerned with giving evidence that the learner is able to perform a job according to the previously determined standards.

(c) Promoting:

It is concerned with promoting pupils to next higher class.

(d) Selecting:

Selecting the pupils for different courses after completion of a particular course structure.

8.4.4.2 Characteristics of Summative Evaluation

(a) It is terminal in nature as it comes at the end of a course of instruction (or a programme).

(b) It is judgmental in character in the sense that it judges the achievement of pupils.

(c) It views evaluation "as a product", because its chief concern is to point out the levels of attainment.

(d) It cannot be based on teachers observations only.

(e) It does not pin-point difficulties faced by the learner.

(f) Its results can be used for placement or grading purposes.

(g) It reinforces learning of the students who has learnt an area.

(h) It may or may not motivate a learner. Sometimes, it may have negative effect.

Examples:

1. Traditional school and university examination,
2. Teacher-made tests,
3. Standardized tests,
4. Practical and oral tests.

Check Your Progress–1

Note: (a) Answer the questions given below.

(b) Compare your answers with those given at the end of this lesson.

I. _____concerned with identifying the learning difficulties or weakness of pupils during instruction.

II. The main objective of the _____is to assign grades to the pupils.

III. Which is not the function of formative evaluation?

(a) Diagnosing (b) Monitoring (c) Certifying (d) Placement

IV. Which evaluation is terminal in nature?

V. The term evaluation is closely re-lated to_____.

VI. The _____examinations are generally summative evaluation tools.

VII. It is concerned with identifying the _____or weakness of pupils during instruction.

VIII. Formative evaluation provides first-aid treatment for simple learning problems whereas diagnostic evaluation searches for the underlying causes of those problems that do not respond to first-aid treatment. (Put true / false).

8.4.5 Norm Referenced Evaluation

Norm-referenced evaluation is the traditional class-based assignment of numerals to the attribute being measured. It means that the measurement act relates to some norm, group or a typical performance.

It is an attempt to interpret the test results in terms of the performance of a certain group. This group is a norm group because it serves as a referent of norm for making judgements.

Test scores are neither interpreted in terms of an individual (self-referenced) nor in terms of a standard of performance or a pre-determined acceptable level of achievement called the criterion behaviour (criterion-referenced). The measurement is made in terms of a class or any other norm group.

Almost all our classroom tests, public examinations and standardised tests are norm-referenced as they are interpreted in terms of a particular class and judgements are formed with reference to the class.

Examples:

(i) Raman stood first in Mathematics test in his class.

(ii) The typist who types 60 words per minute stands above 90 percent of the typists who appeared the interview.

(iii) Amit surpasses 65% of students of his class in reading test. Rating-scales, etc.

A simple working definition

A norm-referenced test is used to ascertain an individual's status with respect to the performance of other individuals on that test.

In the above examples, the person's performance is compared to others of their group and the relative standing position of the person in his/her group is mentioned. We compare an individual's performance with similar information about the performance of others.

That is why selection decisions always depend on norm- referenced judgements. A major requirement of norm-referenced judgements is that individuals being measured and individuals forming the group or norm, are alike. In norm-referenced tests very easy and very difficult items are discarded and items of medium difficulty are preferred because our aim is to study relative achievement.

8.4.6 Criterion-Referenced Evaluation:

When the evaluation is concerned with the performance of the individual in terms of what he can do or the behaviour he can demonstrate, is termed as criterion- referenced evaluation. In this evaluation there is a reference to a criterion.

But there is no reference to the performance of other individuals in the group. In it we refer an individual's performance to a predetermined criterion which is well defined.

Examples:

(i) Raman got 93 marks in a test of Mathematics.

(ii) A typist types 60 words per minute.

(iii) Amit's score in a reading test is 70.

A simple working definition

A criterion-referenced test is used to ascertain an individual's status with respect to a defined achievement domain.

In the above examples there is no reference to the performance of other members of the group. Thus criterion-referenced evaluation determines an individual's status with reference to well defined criterion behaviour.

It is an attempt to interpret test results in terms of clearly defined learning outcomes which serve as referents (criteria). Success of criterion-reference test lies in the delineation of all defined levels of achievement which are usually specified in terms of behaviorally stated instructional objectives.

The purpose of criterion-referenced evaluation/test is to assess the objectives. It is the objective based test. The objectives are assessed, in terms of behavioural changes among the students.

Such type of test assesses the ability of the learner in relation to the criterion

behaviour.Glaser (1963) first used this term, 'Criterion-reference test' to describe the learner's achievement on a performance continuum.

Hively and Millman (1974) suggested a new term, 'domain-referenced test' and to them the word 'domain' has a wider connotation. A criterion referenced test can measure one or more assessment domain.

Check Your Progress – 2

Note: (a) Answer the questions given below.

(b) Compare your answers with those given at the end of this lesson.

I. A _____test is used to ascertain an individual's status with respect to a defined achievement domain.

II. A_____ test is used to ascertain an individual's status with respect to the performance of other individuals on that test.

III. Norm referenced evaluation serves as a referent of norm for making judgements.(put true/ false).

IV. In criterion referenced test, there is reference to the performance of other individuals in the group(put true/ false).

V. Criterion referenced test is the subjective based test.(put true/ false).

VI. A major requirement of _____judgements is that individuals being measured and individuals forming the group or norm, are alike.

VII. Norm-referenced evaluation is the traditional class-based assignment of numerals (put true/false).

VIII. In which evaluation the measurement is made in terms of a class or any other norm group?

8.5 LET US SUM UP

Evaluation

Evaluation is describing something in term of selected attributes and judging the degree of acceptability or suitability of that which has been described. It is a systematic process of collecting, analysing and interpreting in-formation to determine the extent to which pupils have achieved instructional objectives

Types of evaluation

Evaluation can be classified into different categories in many ways.

- On the basis of function
- On the basis of approaches

- On the basis of interpretation

8.6 LESSON END EXERCISE

1. What is evaluation?
2. Explain types of evaluation on the basis of interpretation.
3. Discuss the functions of summative evaluation.

8.7 SUGGESTED FURTHER READINGS

Aggarwal, J.C. (1996). *Principles, Method and Techniques of Teaching,* Vikas Publishing House Pvt. Ltd. New Delhi

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8.8 ANSWERS TO CHECK YOUR PROGRESS

Answers to Check Your Progress-1

i. diagnostic Evaluation.

ii. summative Evaluation.

iii. certifying.

iv. Summative

v. Measurement

vi. Traditional

vii. learning difficulties

viii. true

Answers to Check Your Progress- 2

i. criterion-referenced

ii. norm-referenced

iii. true

iv. false

v. false

vi. Norm- referenced test

EVALUATION TOOLS

Structure

9.1 INTRODUCTION

Evaluation is a series of activities that are designed to measure the effectiveness of the teaching learning as whole process. It is the assessment of systematic planned and quality learning. It helps the teacher to make better judgements in various aspects. So it is important and continuous component. For this purpose we need variety of evaluating tools.

9.2 OBJECTIVES

After going through this lesson, you shall be able to:

- know the various evaluation tools,
- understand the types of evaluation tools, and
- understand the characteristics, merits and demerits of evaluation tools.

9.3 EVALUATION TOOLS

An evaluation tool is a means of appraisal scientifically designed to evaluate or measure what is required to be evaluated or measured.Evaluation is the process which is inevitable in instruction.Tools are the instruments used for measuring the learning outcome. Carefully collected evaluation data help teachers to understand the learners, plan learning experiences for them, and determine the extent to which the instructional objectives are being achieved.

Various evaluation tools

- Diagnostic testing and remedial teaching
- Oral tests

- Quizzes
- Essay type tests
- Objective type tests

9.3.1 Diagnostic Testing and Remedial Teaching

The Meaning of Diagnostic Evaluation

The term 'diagnosis' is borrowed from the medical science. Educational diagnosis Diagnostic evaluation is a pre- assessment of the students where the teacher can evaluate their strengths and weakness before giving the instructions. It is a technical procedure designed to locate specific learning and instructional difficulties and to determine - their causes.

According to Stadola and Stordahl

"A diagnostic test is developed to identify specific strengths and weakness in basic skills such as reading, and arithmetic."

According to Mehrens.

"Diagnostic tests are primarily concerned with the skills or abilities that the subject matter experts believe are essential in learning a particular subject."

According to Payne

"Diagnostic test undertakes to provide a picture of strengths and weaknesses."

Conclusion of the above definitions:-

It is concluded that a diagnostic test is primarily concerned with the process of finding out weaknesses of the pupils in particular subjoin area.

Objectives of Diagnostic Test

1. To provide educational and vocational guidance to students and guardians on the basis of traits realized from specific subject-related learning unit.
2. To make teaching-learning circumstances effective.
3. To make evaluation process more meaningful and effective.
4. To arrange for remedial teaching.
5. To give advice to a teacher for proper improvement in his teacher process.
6. To know about the weaknesses, deficiencies and difficulties of a student.
7. To assist in the selection of different tests, techniques and tools for knowing the causes related to the problem.

8. To assist in the selection of different types of questions for the construction of different achievement tests.

9. To amend textbooks of different subjects on the basis of the specific points and shortcomings and to make them more useful for students.

Characteristics of Diagnostic Test

A diagnostic test should have the following characteristics in order to its beings useful for teachers and students:

1. A diagnostic test is more elaborate, it consist of a large number of items of different levels
2. These tests are standardized
3. Time limit for these tests is not specified.
4. These tests are the essential part of the curriculum.
5. These tests helps to reveal mental process of a learner.
6. These tests are based on the specific objectives.
7. The basis of these tests is formed by such facts or norms which are established on the basis of experiments.
8. These tests do not measure a child's ability, but diagnose his weakness in order to provide remedy.
9. More than one item is included from each teaching point in order to make sure whether the students know thoroughly.
10. A diagnostic test undertakes to provide a detailed picture of strengths and weaknesses in an area.
11. These tests are analytical and analyze all parts of a process fully.
12. These tests, test the progress of a student objectively.

Check Your Progress-1

Note: (a) Write your answers in the space given below.

(b) Compare your answers with the one given at the end of this lesson.

1. Fill in the blanks using the words: (1) detailed, (2) errors, (3) assess, (4) located, (5) identify, (6) analysis.

(i) The aim of class test is to .....the performance of pupils.

(ii) Diagnostic Test implies .....study of learning difficulties.

(iii) In the Diagnostic Testing process the problem is.....through due .....

(iv) Diagnostic Testing means to .....the problem areas.

(v) In Diagnostic Testing we try to find the area where ..... occur.

Construction and Standardization of Diagnostic Test

The subject for which a diagnostic test has to be constructed, is at first analyzed minutely and it is determined what concepts, principles, theories, rules, facts, formulae or processes have to be attached importance. Besides, those mental faculties of students have to be analyzed which are directly related to such knowledge, such as reasoning, logic, thinking power, observation power etc.

A diagnostic test can be individual oriented or group-oriented.

Constructing diagnostic test

Individual oriented group oriented

(a) Individual oriented test :- It comprises of test items that are related to the weaknesses and abilities of a particular student.

(b) Group oriented test :- In it, the test - items are constructed keeping in view the specific group errors or weaknesses. For construction of test items, common and specific errors of the students are collected.

Process of Diagnosis Test

Following are the five important steps of the process of instructional diagnosis :

1. **Selection of Students for Diagnosis**: In this, those students are selected, who are weak in one or more subjects, and are not able to adjust well with some other activities of the school. Such students can be selected on the basis of test results held in school from time to time.
2. **Identify Difficulty Points**: In it, the teacher tries to find out that what type of difficulty is faced by the students. For this, the diagnostic and performance or achievement tests can be administered which can be either teacher-made or standardized.
3. **Analysis of Difficulty Points**: in it, the teacher tries to find out why a student is doing particular type of error again and again, because the mind of each student functions in

a peculiar manner. A teacher can estimate the causes and tries to ascertain them on the basis of his experience or interview.

4. **Remedial Procedures :-** In this step, a suitable plan is made to remove the weakness and error of the student. If a number of students have committed the same type of error, then they maybe treated collectively, and if the error is individual, then it should be remedied individually.

5. **Preventive Measures**: If we desire that a student may not commit any error in the subject in future, then we should effect such changes in his school and domestic environment so that his problem of maladjustment can be permanently eradicated.

Remedial-Teaching

Remedial-Teaching is conducted to eradicate the shortcomings which are found out by the diagnostic tests. The success of remedial measures depends on the fact how widely the teacher knows of the students' shortcomings.

The following factors should be kept in mind, while conducting remedial measures :

(1) The weak students should be asked to sit on the front seats in the class.

(2) The development of the subject matter should be done with the help of examples and illustrations.

(3) The attention of the students should be drawn to those concepts, principles and activities related to the subject matter in which they commit errors.

(4) The fundamental concepts of mathematics and other subjects, such as factors, percentage, unit, square root, etc. should be taught carefully.

(5) The students should be provided sufficient opportunity for thinking and reasoning in the class.

(6) The concepts should be made clear to the weak students by using models, charts and otheraudio-visual aids.

(7) The matter written on the blackboard should be clear, correct, orderly and useful.

(8) The exercises on each sub-topic should be such which the students can think about themselves.

(9) The correction in the written work of the students should be done in their presence.

(10) The students should be given individual counselling even after the class, to help them in learning.

Educational Diagnosis and Remedial Teaching

Diagnostic test is constructed for educational diagnosis, and remedial teaching is conducted on the basis of diagnosis. We shall clarify it by an example.

For example, take teaching of a sub-topic of mathematics: square root. Suppose, after the teacher has taught the method of finding out square root, some of the students still commit error in it. The teacher will conduct diagnostic and remedial work in this order:

1. First, the teacher will construct different questions of decimal numbers to find out square root; such as;

(a) Find out square root of the following numbers:

(i) 1355.23 (ii) 25.2143 (iii) 44.135678

(b) Find out square root of the following numbers up to two decimal points:

(i) 210.7 (ii) 12345.071 (iii) 7.0357

2. He will give this question paper to the group of students which commits errors.

3. He will analyse the students' answers and then arranges their causes.

Suppose, the students commit the following errors in solving the above questions:

(a) Some students do not take down the pairs of numbers while calculating square root.

(b) Some students do not pay attention to decimal point while making pairs.

(c) Some students do not add zero after decimal point to make pairs.

4. On the basis of the above errors, the teacher will classify the students and prepare their lists; such as — the list of students who do not take down the pairs correctly, the list of students who overlook the decimal point, and the list of students who do not add zero after decimal point to make pair,

5. After this, the teacher will formulate different types of hypotheses. These hypotheses will be formulated on the basis of student-related hindering factors, teacher-related hindering factors, home-related hindering factors and culture related hindering factors. Some of the student related and teacher-related hypotheses are given here, for illustration:

(i) The student is not attentive in the class.

(ii) The student thinks that mathematics is a difficult subject and overlooks to learn it.

(iii) There is no coordination between the rate of students' learning and teacher's teaching.

(iv) The student has not done sufficient exercise.

(v) The teaching method is not suitable.

(vi) The teacher has not made the students practice enough.

(vii) The teacher has not improved the errors in checking work.

In the same way, if the teacher considers it necessary, he can also formulate hypotheses about curriculum-related, home-related, guardians-related and culture-related hindering factors.

6. The teacher will construct questions to test various types of hypotheses.
7. The teacher will select correct hypotheses by analysis of the answers to these questions.
8. At last, the teacher will conduct remedial teaching on the basis of correct hypotheses.

Check Your Progress-2

Note: (a) Answer the questions given below.

(b) Compare your answers with those given at the end of the lesson.

1. The _____depends more on the teacher, and less on the form of the test. Time limit for diagnostic tests is not specified. (Put true / false).
2. _____is conducted to eradicate the shortcomings which are found out by the diagnostic tests.
3. Which test helps the teacher to find out what type of difficulty student is facing?
4. Diagnostic tests and remedial teaching are not related to each other. (Put true / false)
5. The correction in the written work of the students should not be done in their presence. (Put true / False)
6. Diagnostic tests are standardized. (Put true / false)
7. The diagnostic tests are useful only when the causes found are removed. (Put true / false)

9.3.2 ORAL TESTS

An oral test is a direct means of assessing student's learning outcomes by questioning them. Oral tests does not have a structured list of questions.

Types of Oral Tests

(a) Oral test after a direct observation test:-

An oral test is often used as part of a de-briefing session after a practical has been observed. The time duration is usually 3-5 minutes. There is no formal structure.

(b) Oral in the form of a viva voce:-

Vivas are traditionally conducted by an external and an internal examiner. There is no set time limit for a viva voce, but a full day examination is often normal.

(c) Oral/Aural in a language setting:-

Oral in a language setting is a direct speaking test geared at assessing a student's level of speaking proficiency. Aural in a language setting is a listening test that us made to check the student's level of hearing proficiency.

Structure of Oral Test

The structure of an oral assessment depends on the type of oral assessment, but in general, the followings are used.

Depend on which type of oral assessments, it is sometimes desirable to allow the student to start the oral assessment by giving an account of the analysis of the practice..

Probing questions – to initiate and engage the student in conversation. Questions such as: How did you know that? What method did you use to arrive with that conclusion?

Prompting questions – to give hints that point the student to the right direction to clarify his response, this however does not mean the assessor answers the questions himself.

Challenging questions – to assess the deep understanding - the higher level of Blooms taxonomy. Questions such as: Can you justify why your method is more efficient than Prof. Einstein's?

Advantages of Oral Test

- There can be no plagiarism or false reports.
- Assessors receive immediate reactions and responses.
- It complements perfectly with practical assessments.

Disadvantages of Oral Test

- Oral Test is very time-consuming, it is an expensive way of assessing.
- Validity is high but reliability is not. Clear assessment criteria and grading are required for all parties so that students and assessors are fully aware of how the performance will be judged to increase reliability.
- There are rarely any clear guidelines about what is fair to judge at a viva. There have

been some contentious cases that the assessor has rejected (?) or even failed a dissertation because the assessor is unwilling to accept the results of a candidate due to difference in opinions. Although there will be examiners' reports, there is rarely any record of the process itself to ensure its fairness.

- Oral tests may present significant difficulties for international students or students with certain impairments, who may require access to an alternative type of assessment that provides an acceptable test of learning outcomes. Students with some other impairments may be able to undertake oral assessment but may require some adjustments in order to have an equal footing.
- Immediate feedback is useful, but sometimes that is difficult due to time constraints.
- Oral test is usually ephemeral, and dissenting views may later be contested if notes or recordings are not documented clearly.

How to design a good Oral Test?

Ensure the students know what the objectives of the assessment are.

- Provide students the time period, location, guidelines, requirements, assessment criteria and if there are items that are not to be included. The students should also be aware of who is going to assess them – tutor, peers and/or self? And if peers or themselves are going to assess, would the weightings be the same as the tutor's assessment?
- Prepare a structured marking sheet for all assessors.
- Give sufficient time for students to respond.
- Teacher should incorporate oral assessment into the practice of teaching during class, e.g. how to think out loud.

9.3.3 Quizzes

Quiz is a form of student assessment that measures knowledge, skills, and abilities. A quiz is generally a frequent and short assessment that can gauge a student's retention and comprehension of a small amount of information. A quiz can function throughout a course as an informative feedback device allowing both the instructor and the students to see where they are excelling or need more focus.

Types of Quizzes

Below, we've outlined the nine most common types of quizzes.

1. Personality Quiz

Personality quizzes are among the most common types of quizzes, as they can be

used form any different purposes and in many different forms. Personality quizzes can be serious, fun, or educational.

2. Scored Quiz

A scored quiz, also known as a tally quiz, is commonly used in online tests and assessments. Each question is assigned a point value. Upon completion, your total score is tallied with your outcome based on the final numbers

3. Multiple Choice Quiz

In it, you're presented with a question and a set of answers. Every question has one right answer, with the outcome based on the number of correct answers.? You can use a multiple-choice quiz in many ways,

4. Yes or No Quiz

This is the simplest type of assessment-based quiz. While it's similar in some ways to a multiple-choice quiz, there are only two answers to choose from i;e yes or no.

It's a concise and efficient way to judge a person's knowledge on a subject or receive feedback. For example: Did you understand the primary purpose of the presentation?

5. True or False Quiz

A true or false quiz also has one answer. As one of the quickest types of quizzes to create, these are commonly used in a variety of applications. There's one right answer and one wrong answer. This makes it easy to administer and grade.

6. **Poll**

A poll is an interactive quiz that includes only 1 question. Upon completion of the poll, you can check your statistics for the following:

Impressions

Vote percentage

Result report

Responses report

7. Knowledge Tests

A knowledge test is one in which each question has a correct answer. It's among the most formal types of test. The goal of a knowledge test is to test a person's knowledge on a particular subject.

8. Survey

It's not the same as a traditional quiz, as a survey is designed to gather feedback or

lead the user to an outcome based on answer (known as skip logic).However, depending on the way you format the survey, it can take on a "quiz-like" form. The most powerful feature of a survey is skip logic. With this, you can display questions based on the respondent's answers.

What's the Difference Between a Quiz, Test, and Exam?

Different But The Same

First, yes, they're the same, and yes, they're different. Confused? Let's explore the subject a bit then. Your thesaurus is likely to say that all three of these words are interchangeable. And in fact, sometimes they are used interchangeably. "Test" and "exam" especially are often used in the same context. However, especially in high school and college, there are subtle differences.

9.3.3 QUIZZES

A quiz is usually a short test. The instructor use the quiz just to check up on how well you're understanding the material. A quiz might instead have just 8 or 10. Although they vary according to the instructor and the quizzes They don't often have interpretive questions.

Tests

These are the standard evaluation technique used to determine your grade in both high school and college classes. The test score is used in determining your grade in the class. A test normally covers a longer chunk of the course: a whole unit or several chapters. For this reason, tests are commonly longer than quizzes.

Exams

Many instructors use "test" and "exam" interchangeably, but for students, an exam refers to either a mid-term or final exam. It's the granddaddy of tests in both high school and college. You can expect that an exam will be long (long enough that most college instructors allow hours rather than minutes for it to be taken). For instance, some instructors consider the exam grade as one third of your total score for the class.

9.3.4 Essay Type and objective type tests

9.3.4.1 Meaning: Essay Type Test Notes

An essay test is an assessment technique that requires students to thoroughly respond to a question by developing, organizing, and writing an original composition. The purpose of an essay test is to assess students' abilities to construct a logical, cohesive, and persuasive writing piece.

9.3.4.2 Extended and Restricted Response Essay Type Test

(a) Extended essay type test:- Extended response variety suits better at higher levels like the colleges or university. When thorough understanding of a set of topics or units is the objective of testing and best presentation of the subject-matter is to be appreciated, this variety of extended response of ETQ is the best to take advantage of.

(b) Restricted response type test :- the restricted response variety of ETQ is favoured more for secondary and senior secondary stages. Restriction is imposed and examinees cannot be expected to write extended responses, these types of questions are termed restricted-response essay-type questions. if the focus of measurement of learning outcomes is on interpretation, application of data or outcomes that are more specific and that clearly define the nature of the intended response and attempt to reduce subjectivity in marking, the restricted response variety of ETQ can be preferred.

To appreciate the difference between the two types of ETQ, let us take the example:-

(i) Write an essay on India's struggle for independence.

(ii) Discuss in details the various theories of organic evolution.

(iii) Describe various allotropic forms of carbon.

(iv) In what way Kalinga war influenced King Asoka?

(v) Describe the laboratory method of preparing oxygen gas.

(vi) Write in about 150 words an essay on 'A Village Fair'.

The questions (i) to (iii) are classified as extended-response questions and ETQ. But in questions (iv) to (vi) there is restriction response essay type test.

9.3.4.3 Principles of Constructing Essay Type Test

General Hints

(i) Use ETQ where you must and avoid where you can.

(ii) Try to increase the number of questions by including more questions of restricted-response variety in preference to extended-response variety.

(iii) Avoid giving choice, especially free options (6 out of 9 type), in ETQ to discourage teaching and selective learning besides ensuring better comparison of students.

(iv) If only ETQ are included in a question paper, ensure wider range of difficulty level to cater to poor, average and right students using lower-order, middle-order and higher-order questions.

(v) Frame each question keeping in view the stipulated time requirement.

(vi) Write explicit and clear instructions for examinees to enable them to attempt questions on similar lines for similar goal.

Specific Hints

(i) Pinpoint the specific assessment objectives, which becomes the basis of your question.

(ii) Select content clusters from one or more content areas of syllabus which are relevant to assessment objectives.

(iii) Use familiar and appropriate directional words that evoke the desired responses and demand exercise of intended mental process (list, describe, compare, discuss, justify, evaluate etc.).

Avoid directional words like 'what do you know of, 'write short notes on', 'give an account of' etc.

(iv) Structure the question to pinpoint the area of response and delimit the scope of expected response, by proper wording of the question.

(v) Avoid semantic difficulties by using simple, precise and unambiguous language.

(vi) Set task in the question that require students to demonstrate command of the essential knowledge, not the factual information.

(vii) Indicate clearly part-wise marks for each question that has more than one parts, e.g. Define germination. What are the conditions necessary for germination? Illustrate with the help of an experiment. (2 + 3 + 5)

(viii) Write model answer to test the efficacy of your questions. It helps improve the question if needed.

(ix) Work out the marking scheme, indicating major value points and their corresponding marks and the mode of deduction of marks, if any.

9.3.4.4 Improving in Reliability of Scoring Essay Type Test

The following measures may be adopted to control the reliability of ETQ:

(a) Use precise, unambiguous and understandable language to enable the examinees to think about the expected scope of answer in the same way as intended by the framer of the question.

(b) Reshuffle answer scripts after marking each question to reduce the carryover effect.

(c) Use double grading when the test is being used for selection or awarding scholarship.

(d) Marks of the scripts may be totalled at the end after marking all the scripts to avoid

carry over of any impression formed about the quality of the script, when the marks are totalled.

(e) Avoid contamination of scores by avoiding extraneous factors like spelling, handwriting, punctuation, neatness etc.

(f) To reduce inter-examiner reliability, examiners may meet together after marking some scripts to discuss the marking scheme and compare marking.

(g) Allocation of scripts question-wise to each examiner improves scoring objectivity, because the examiner scores the same question in all the scripts.

Despite various limitations, ETQ have come to stay in spite of their low validity and reliability.

9.3.4.5 Advantages of Essay Type Test

There are following advantages of Essay type test

(i) Such tests induce good study habits in the pupils.

(ii) The guess work can be eliminated to large extent.

(iii) Such tests are easier to prepare and administer.

(iv) By this type of tests it is possible to measure all degrees of comprehensiveness and accuracy.

(v) Such tests can be used by all type of schools.

(vi) These help in developing the po0wer of logical thinking, critical reasoning, systematic presentation etc. in the students.

(vii) Such tests provide an opportunity to the child to show his initiative, originality of thought, fertility of their imagination, etc.

(viii) This type of tests are considered to be best for measuring ability to organise idea effectively, ability to criticise or justify a statement, ability to interpret etc.

9.3.4.6 Limitations of Essay Type Test

(a) Defects from the Point of View of Students

(i) The essay type tests are less objective and so they lack of validity. This type of test can reveal child's cramming capacity only.

(ii) These tests lack reliability. A student is compelled to have a selective reading. He depends more on guess papers and so there is an element of chance.

(iii) It keeps the students busy and fall of nervous tension. The study does not spread over

the whole year and is limited to a short period just before the examinations. Thus, a habit of irregular study is developed in the student.

(b) Defects of Essay-type Tests from the Point of View of the Teacher:-

(i) The teacher covers only a limited and important portion of course because his aim is to see that maximum number of his students pass the examination.

(ii) The teaching programme of the teacher is wholly examination oriented and the basic principle of teaching his students are given least consideration.

(iii) The teacher is compelled to encourage his students to cramming which is not a psychological method of teaching.

(iv) Since a teacher is judged by the results of his students so everything becomes subservient to the examinations.

(v) To show good results sometimes the teacher devotes a good deal of his time to indulge in guess work which affects his teaching

(c) Defects from the Point of View of Achievement:-

(i) Essay type tests are not comprehensive and some students may get good marks only because the questions have been set from the portion prepared by them.

(ii) These tests are not objective and the score of a student depends on various factors such as Examiners mood and whims etc.

(iii) This type of tests is not useful from the point of view of improvement. They fail to throw light on the defects of teaching-learning process or the defects of the curriculum.

From the above it can be concluded that essay type examination is not a correct method of evaluation in commerce. The improvement in system of evaluation is possible if following suggestions are given due consideration.

Check Your Progress-3

Note: (a) Answer the questions given below.

(b) Compare your answers with those given at the end of the lesson:

(1) An essay test is an _____technique that requires students to thoroughly respond to a question.

(2) The purpose of an essay test is to assess student's _____ (abilities/aptitudes).

(3) Write any two advantages of essay type tests.

(4) Most of the higher order abilities demand inter-disciplinary and intra-disciplinary subject-matter (True/false).

(5) Critical analysis of content can better be tested by using essay type questions.
(True/false)

(6) Essay type questions suits better for _____ subjects.

(7) Name two types of essay type tests?

9.4 Objective type test

9.4.1 Meaning of Objective Test

An objective test item is defined as one for which the scoring rules are so exhaustive and specific that they do not allow scorers to make subjective inferences or judgements. Several types of questions are asked in them. These questions are generally classified into two types:

i. Recall type question

ii. Recognition type questions.

9.4.2 Objective Test Formats

A variety of different types of objective test formats can be classified into two categories:-

1. **Selected response format,** in which examinees select the response from a given number of alternatives, including true/false, multiple choice, matching test items; and
2. **Constructed response format**, in which examinees are required to produce an entire response, including short answer test items.

9.4.3 Construction of Objective Test Items

Basically, scoring objective test items is easy: It only requires one to follow the scoring rules. However, constructing good objective test items requires much more skill and effort. The first step is

- **To develop a set of test specifications** that can serve to guide the selection of test items. A table of specifications (or test blueprint) is a useful tool for this purpose. This tool is usually a two-way grid that describes content areas to be covered by the test.
- **Appropriate test item format is selected** for each item. At this point, not only objective test items but also other types of test items like essay test or performance assessment should be considered, depending on the learning outcomes to be measured.
- **To create specific test items.** It is particularly important for objective test items to

be written in clear and unambiguous language to allow examinees to demonstrate their attainment of the learning objectives. If complex wording is used, the item simply reflects reading comprehension ability.

9.5 TRUE/FALSE ITEMS

The format of items that represent true-false and allied varieties requires examinees to select the answer from two alternatives, which remain the same for the whole series of items. These items are usually in the form of statements. These items may also take the form of Yes-No, agree-disagree, synonym antonyms, correct-wrong etc.

Forms of Constant Alternative Items

(a) True-False variety (T/F)

(i) Temperature remaining the same, pressure in a gas varies directly proportional to its volume.

(ii) Star fish belongs to the class Pisces. (T/F)

(b) Right-Wrong variety (R/W)

(i) Chandigarh is the capital of both Haryana and Punjab. (R/W)

(ii) Isosceles triangle has all the three sides equal. (R/W)

(c) Agree-Disagree variety (A/D)

(i) Every religion teaches hatred for other religions. (A/D)

(ii) All religions emphasise the same tenets of good living. (A/D)

(d) Yes-No variety (Yes/No)

(i) Is potato an underground stem?

(ii) Does a water pump work on the principle of air pressure? (Yes/No)

9.5.1 Construction of Objective-based True-False Items

It looks easy to frame T/F items, but construction of good T/F items requires insight into their structure. **It involves:**

(a) selection of good concept. principle proposition;

(b) restating the essence of the idea

(c) finding its implications

(d) couching its an thesis

(e) writing the item using the same essential point for one true and one false version.

9.5.2 Matching-Type Items

Design

Matching-type items are prescribed as set of terms, events, phrases, definitions etc., called the premises, which are written on the left-hand side, say **column I.**

Another set of name pictures, statements etc., called the responses, are placed on the right-hand side under **column II.** Students are asked to match each item with the corresponding response, which is considered as one test item.

Relationship may be between a term and definition, object and its functions, inventor and inventions, author and work, dates and events, problems and solutions etc. If the number of responses are equal to the number of premises, it is termed perfect matching.

9.5.3 Rearrangement-Type Items

Examinees are required to re-arrange the randomly presented material into some spe**c**ified order. Material may be presented in the form of a series of statements one after the other or responses maybe given of the multiple-choice type. Direction is to be provided whether the responses are to be rearranged by writing them in specified order; to serial them into particular order; or indicate the serial number of each response etc.

9.5.3.1 Types of Re-arrangement Items

- **Chronological Order**

Rewrite the serial number of the Indian Presidents listed below from past to present according to chronological order in the space provided.

1. A.P.J. Abdul Kalam 3. S.D. Sharma (4-2-3-1)
2. Giani Zail Singh 4. Rajendra Prasad

- **Functional Order**

Rearrange the following steps involved in the manufacture of food by plants in order of their occurrence, giving the serial number in the bracket provided against each.

1. Splitting of water (3)
2. Formation of starch (5)
3. Excitation of chlorophyll (1)
4. Evolution of oxygen (4)
5. Formation of A.T.P. (2)

9.5.4 Structured Questions

Concept

Such questions are rooted in a given stipulated situation, providing the needed introductory statement in the form of a passage, experimental data, table, or diagram, followed by a number of sub questions based on the subject matter.

Chart: Format of structured questions

- **Principles of Construction**

(a) Same introductory paragraph or material is to be used for each question.

(b) Introductory material should neither be inadequate nor have redundant matter.

(c) Sub questions may be of short-answer or objective type. Usually the same form of question is used in one set.

(d) Each sub question must demand reading of introductory paragraph for answering.

(e) Each sub question must be independent and should not depend on knowledge of previous questions.

(f) Each question should test different abilities as far as possible.

(g) All questions must test high-order abilities – not simply recall.

(h) Sub questions may be arranged according to abilities tested, difficulty level, sequence of events or concepts involved.

(i) Such questions should be time effective by keeping limited number of questions.

9.5.5 Multiple-Choice Questions (MCQ)

The most potential and usable form of objective tests is the MCQ. These questions are either used exclusively as in some selection tests, or in combination with other forms of questions.

Exclusive use of MCQ is warranted in all such situations where100% scoring objectivity, time constraint, computerisation of results, machine scoring, ranking, post examination statistical moderation and record of psychometric properties of items are considered the necessary conditions or requirements.

The multiple-choice items are based on response-directed stimulus, in which responses or options may be arranged in different ways. The choice of the correct answer among the given options can be made from the independent set of responses given for each item or from the same set of responses given for different items MCQ may be used exclusively to ensure complete objectivity in scoring.

9.5.6 Objective Test Items

9.5.6.1 Advantages of Objective Test

The objective tests have all the qualities of a good test, though all the abilities of the students cannot be measured by them.

1. **Validity**: Objective tests are generally made to measure the knowledge of the students. First, the questions asked pertain to the field, the knowledge of which has to be measured. Second, the number of questions is generally large which is spread out on the entire range of knowledge.

   Third, the evaluation of these questions is objective. So these tests are valid.

2. **Reliability**: These tests are reliable. All the questions contained in them are clear and bear only one meaning, and their answers too are definite. These are very comprehensive.

3. **Objectivity**: The questions asked in these tests are clear and have a single meaning, their answers are also definite and the evaluator has not any liberty to mark them.

4. **Comprehensiveness**:- small questions are asked in these tests and the answers to these questions are given in one mark, number or word.

5. **Discriminative**; The questions in these tests are spread out on the whole course and are of several types. Some questions have to be answered using recall, some have to be answered by knowledge, and some questions have to be answered using logic and prudence; so the classification of the students done on their basis can be reliable.

6. **Practicability**: Making objective test questions is a difficult task. It takes time to construct so many questions. Marking them too takes time. So now in order to save effort, only multiple-choice questions are constructed and their answers are marked on an answer-sheet which can be evaluated by computer. Thus, the construction, administration and evaluation of these tests have become practicable.

9.5.6.2 Limitations of Objective Test

Despite having all the merits of a good test, these tests are not devoid of some shortcomings.

1. **Measurement of Cognitive Aspect Only**; These tests help to measure the cognitive aspect of the students; these are unsuitable for the measurement of the conative and affective aspects.

2. **Measurement of Memory Power Only**: These tests generally examine the power of memory; the students have to hardly use the higher mental faculties such as logic and thinking.

3. **No Measurement of Language skill and Expression Power**: These tests do not

help in the measurement of language skill and power of expression of the students, so we cannot rely on them for language tests. It is considered to be the biggest demerit of these tests.

4. **Difficulty in Construction of Questions**: According to some scholars, it is very difficult to construct the objective questions for these tests. They consider it a demerit of these tests. We are, however, of the view that these questions can be constructed easily by taking a little interest and care. It depends on interest and practice.

5. **Administrative Difficulty**: These tests are expensive and present difficulties in evaluation.

6. **Fluke Answers**: Some people opine that these tests can be answered in a fluke. It is true, but we have already invented a statistical method to control it, which is called negative marking.

7. **Use of Unfair Means**: It is often heard that the students can easily copy in these tests. In our view, this demerit has occurred due to inexperienced people. The fact is that if a student copy from a book or notebook, he cannot answer all questions in the prescribed time.

Check Your Progress-4

Note: (a) Answer the questions given below.

(b) Compare your answers with those given at the end of the lesson.

(1) Scoring rules for objective test item are so _____ and _____.

(2) Objective test item allow scorers to make subjective judgements.
(True/false)

(3) Name two types of objective type tests?

(4) Multiple choice type questions is a form of _____ type questions.

(5) Objective test format can be classified into two categories (True/false).

(6) An entire response is required in a _____ response format.

(7) The construction of good objective test item requires more skills and effort.
(True/false)

9.6 LET US SUM UP

An instrument to transfer and implement educational objectives into a practice which engage participants in the learning process.

Evaluation tools:

- Diagnostic testing and remedial teaching
- Oral tests
- Quizzes
- Essay type tests
- Objective type tests

9.7 LESSON END EXCERCISE

1. What are evaluation tools?
2. Explain the concept of oral tests?
3. Develop an objective type test (MCQ)?

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9.9 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress-1

(1) Assess

(2) Detailed

(3) located, analysis

(4) identify

(5) errors

Check Your Progress-2

1. Diagnostic test
2. True
3. Remedial-Teaching
4. diagnostic test
5. false
6. false
7. true
8. false

Check Your Progress-3

1. Assessment
2. Abilities

3. True
4. True
5. Language
6. Extended and restricted response
7. (i) Such tests induce good study habits in the pupils.
   (ii) The guess work can be eliminated to large extent.

Check Your Progress-4

1. Exhaustive and specific
2. False
3. Recall type and recognition type questions
4. Recognition
5. True
6. Constructed
7. True

———————

Lesson No. : 10 **Unit : IV**

REFLECTION

Structure

10.1 INTRODUCTION

Dear students, we see a variety of objects in the world around us. However, in a dark room we are unable to see anything. On lighting up the room, things become visible. What makes things visible? During the day, the sunlight helps us to see objects.

An object reflects light that falls on it. This reflected light, when received by our eyes, enables us to see things. We are able to see through a transparent medium as light is transmitted through it. Light is a form of energy, which includes the sensation of vision in our eyes and make us able to see various things present in our surrounding. There are a number of common wonderful phenomena associated with light such as image formation by mirrors, the twinkling of stars, the beautiful colours of a rainbow, bending of light by a medium and so on. A study of the properties of light helps us to explore them. By observing the common optical phenomena around us, we may conclude that light seems to travel in straight lines. The fact that a small source of light casts a sharp shadow of an opaque object points to this straight-line path of light, usually indicated as a ray of light. In this lesson, we shall study the phenomena of reflection of light using the straight-line propagation of light. This basic concept will help us in the study of some of the optical phenomena in nature.

10.2 OBJECTIVES

After going through this lesson, you shall be able to:

- explain the reflection of light at curved surfaces, and
- state how images are formed by spherical mirrors.

10.3 REFLECTION OF LIGHT AT CURVED SURFACES

A highly polished surface, such as a mirror, reflects most of the light falling on it. You are already familiar with the laws of reflection of light. The laws of reflection can recalled as under:

(i) The angle of incidence is equal to the angle of reflection, and

(ii) The incident ray, the normal to the mirror at the point of incidence and the reflected ray, all lie in the same plane.

These laws of reflection are applicable to all types of reflecting surfaces including spherical surfaces. You are familiar with the formation of image by a plane mirror. Image formed by a plane mirror is always virtual and erect. The size of the image is equal to that

of the object and is laterally inverted. The image formed is as far behind the mirror as the object is in front of it. Now let us study about the images formed by curved surfaces.

10.4 SPHERICAL MIRRORS

The most commonly used type of curved mirror is the spherical mirror. The reflecting surface of such mirrors can be considered to form a part of the surface of a sphere. Such mirrors, whose reflecting surfaces are spherical, are called spherical mirrors.

The reflecting surface of a spherical mirror may be curved inwards or outwards. A spherical mirror, whose reflecting surface is curved inwards (faces towards the centre of the sphere), is called a concave mirror [Fig. 10.1 (a)]. A spherical mirror whose reflecting surface is curved outwards, is called a convex mirror [Fig. 10.1 (b)]. The schematic representation of these mirrors (back of the mirror is shaded) is shown in Fig. 10.1.

(a) Concave mirror (b) Convex mirror

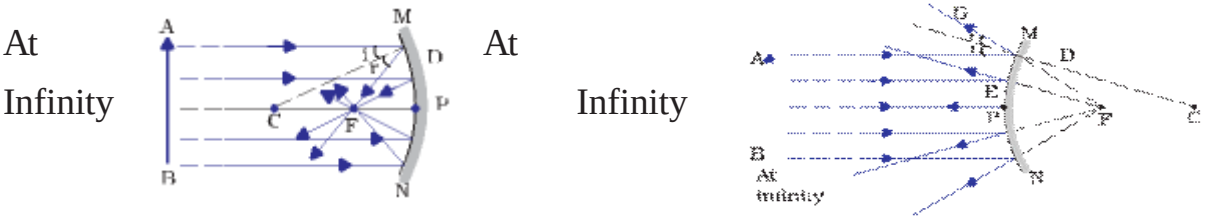
Figure 10.1 **Schematic representation of spherical mirrors**

Now one analogy with spoon can be drawn here. The surface of the spoon curved inwards can be approximated to a concave mirror and the surface of the spoon bulged outwards can be approximated to a convex mirror.

Now it is important to know the terms commonly used in discussions about spherical mirrors. The centre of the reflecting surface of a spherical mirror is a point called the pole. It lies on the surface of the mirror. The pole is usually represented by the letter P.

The reflecting surface of a spherical mirror forms a part of a sphere. This sphere has a centre. This point is called the centre of curvature of the spherical mirror. It is represented by the letter C. Please note that the centre of curvature is not a part of the mirror. It lies outside its reflecting surface. The centre of curvature of a concave mirror lies in front of it. However, it lies behind the mirror in case of a convex mirror. You may note this in

Fig.10.2 (a) and (b). The radius of the sphere of which the reflecting surface of a spherical mirror forms a part, is called the radius of curvature of the mirror. It is represented by the letter R. You may note that the distance PC is equal to the radius of curvature. Imagine a straight line passing through the pole and the centre of curvature of a spherical mirror. This line is called the principal axis. Remember that principal axis is normal to the mirror at its pole.



(a) (b)

Figure 10.2 **(a) Concave Mirror (b) Convex Mirror**

Figure 10.2 (a) demonstrates that a number of rays parallel to the principal axis are falling on a concave mirror. Observe the reflected rays. They are all meeting/intersecting at a point on the principal axis of the mirror. This point is called the principal focus of the concave mirror. Similarly, Fig. 10.2 (b) reflects that the reflected rays appear to come from a point on the principal axis. This point is called the principal focus (F) of the convex mirror. The distance between the pole and the principal focus of a spherical mirror is called the focal length (f).

The reflecting surface of a spherical mirror is by and large spherical. The surface, then, has a circular outline. The diameter of the reflecting surface of spherical mirror is called its aperture. In Fig.10.2, distance MN represents the aperture. Here only such spherical mirrors are discussed whose aperture is much smaller than its radius of curvature. For spherical mirrors of small apertures, the radius of curvature (R) is found to be equal to twice the focal length. We put this as $R = 2f$. This implies that the principal focus of a spherical mirror lies midway between the pole and centre of curvature.

Check Your Progress-1

Note: (a) Answer the questions given below.

(b) Compare your answers with those given at the end of this lesson.

1. Fill in the blanks:

(a) A spherical mirror, whose reflecting surface is curved inwards, that is, faces towards the centre of the sphere, is called a _____.

(b) A spherical mirror whose reflecting surface is curved outwards, is called a _____.

(c) The diameter of the reflecting surface of spherical mirror is called its _____.

(d) If the radius of curvature of a spherical mirror is 10 cm. Its focal length is _____.

2. Choose the correct option for the following questions:

A. The centre of the reflecting surface of a spherical mirror is a point called the _____.

(a) Focus

(b) Pole

(c) Curvature

(d) Focal length

B. The principal focus of a spherical mirror lies _____.

(a) midway between the pole and centre of curvature

(b) at the pole

(c) at the centre of curvature

(d) far beyond the centre of curvature

10.5 REPRESENTATION OF IMAGES FORMED BY SPHERICAL MIRRORS USING RAY DIAGRAMS

Diagrams are used to depict the image formation by tracing the path of light rays i.e. incident rays and reflected rays. They are drawn in order for anyone to view a point on the image of an object. These ray diagrams depend on the position of the object.

10.5.1 Ray Diagrams for a Concave Mirror

For a concave mirror, there are six possible positions (Fig 10.3 to Fig 10.8) where the object can be positioned and an image is formed:

a. Object is positioned at infinity

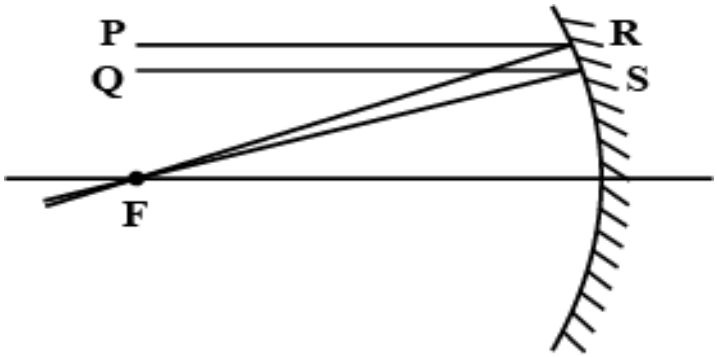


Figure 10.3: **Object is positioned at infinity**

When the object is placed at infinity, rays PR and QS parallel to the axis are reflected from points R and S respectively. Rays PR and QS intersect each other and get converged at the principal focus (F). And since when the object is placed at infinity, the properties of the images formed are highly diminished, point sized and real and inverted.

b. Object is positioned between infinity and Center of Curvature (C)

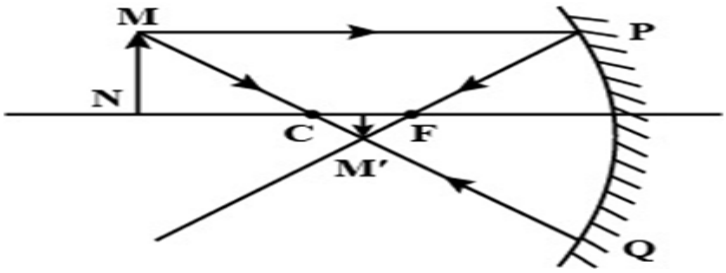


Figure 10.4: **Object is positioned between infinity and center of curvature (C)**

Here the object MN is placed between infinity and center of curvature (C) of a concave mirror, then a ray MP parallel to the principal axis and another ray MQ that pass through the center of curvature (C) intersect each other at M' after reflection between focus (F) and center of curvature (C). Therefore, the properties of the images formed here are that the image formation

is between principal focus (F) and center of curvature (C), the image formed is diminished and real and inverted.

c. Object is positioned at Center of Curvature (C)

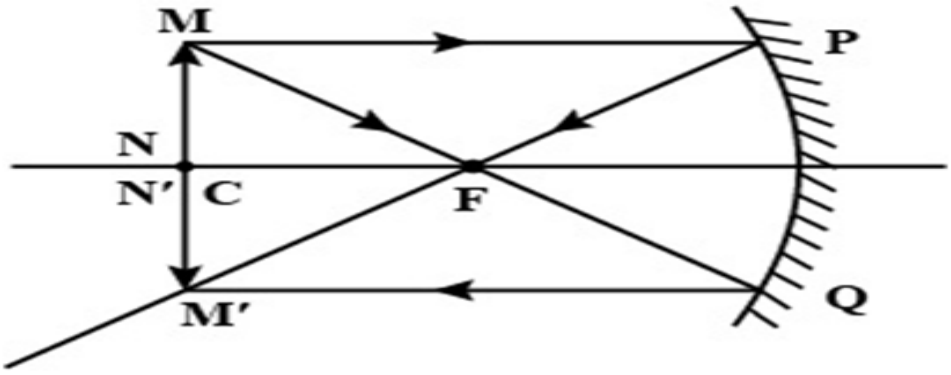


Figure 10.5: **Object is positioned at center of curvature (C)**

When the object MN is placed the at the center of curvature (C), then a ray MP parallel to the principal axis and another ray MQ that passes through the principal focus (F) after reflection, intersect each other at point M' right below where the object MN is positioned. Hence, the properties of the images formed in this case are that image is formed at the center of curvature, the image is the same size as the object and images are real and inverted.

d. Object is positioned between the center of curvature (C) and principal focus (F)

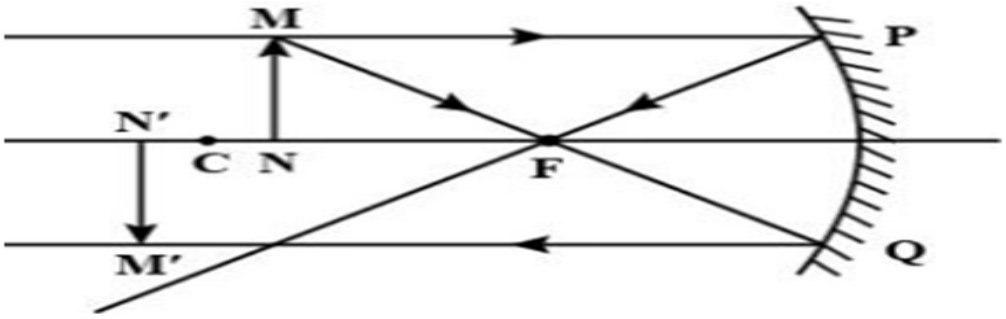


Figure 10.6: **Object is positioned between the center of curvature (C) and principal focus (F)**

Object MN is placed between the center of curvature (C) and principal focus (F), then the ray MP parallel to the principal axis and another ray MQ passing through principal focus (F) intersect each other beyond the center of curvature (C) at point M'. Hence, the properties of the

images formed here are that the image is formed beyond the center of curvature (c), and the image is real and inverted.

e. Object is positioned at Principal Focus (F)

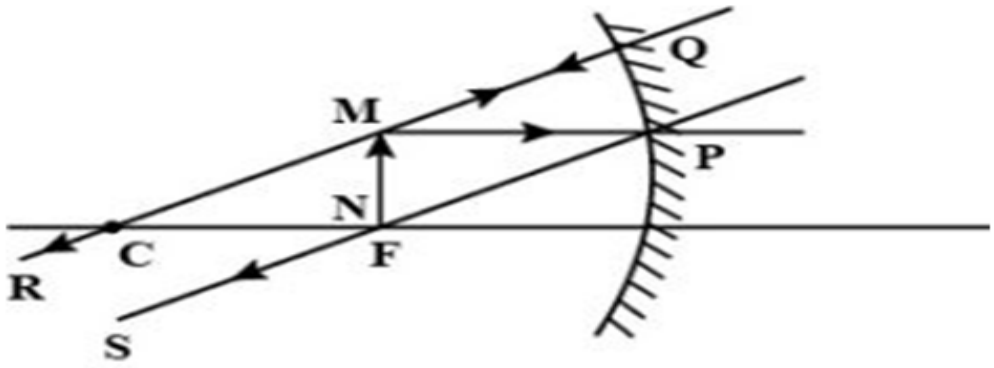


Figure 10.7: **Object is positioned at principal focus (F)**

Object MN is positioned at the principal focus (F), then ray MP parallel to the principal axis passes through principal focus (F) giving the reflected ray PS. Second ray MQ that passes through the center of curvature is reflected along the same path giving the reflected ray QR. Here, since the rays, PS and QR become parallel to each other and therefore the image formation is at infinity. Here the properties of the images formed are highly enlarged images and real and inverted images.

f. Object is positioned between principal Focus (F) and Pole (P)

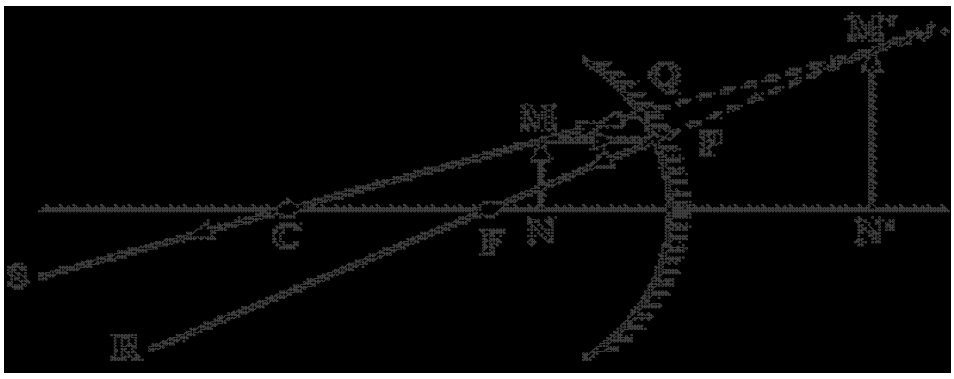


Figure 10.8: **Object is positioned between principal focus (F) and pole (P)**

Object MN is positioned between principal focus (F) and pole (P), then the ray MP parallel to principal axis passes through principal focus (F) giving the reflected ray PS and the

second ray MQ that passes through the center of curvature (C) is reflected along the same path giving the reflected ray QR.

Now, since the reflected rays PR and QS are diverging away hence cannot intersect each other, hence reflected rays PS and QR are extended behind the mirror by dotted lines. In doing so, rays PR and QS appear to intersect each other at point M' backwards. Therefore, the properties of the images formed here are formed behind the mirror, images are highly enlarged, images are virtual and erect.

Table 1

Image formation by a concave mirror for different positions of the object

Position of the Object	Position of the Image	Size of the Image	Nature of the Image
At Infinity	At the focus of F	High diminished, Point-sized	Real and inverted
Beyond C	Between F and C	Diminished	Real and inverted
At C	At C	Same size	Real and inverted
Between C and F	Beyond C	Enlarged	Real and inverted
At F	At Infinity	Highly enlarged	Real and inverted
Between P and F	Behind the mirror	Enlarged	Virtual and erect

Uses of concave mirrors

Concave mirrors are commonly used in torches, search-lights and vehicles headlights to get powerful parallel beams of light. They are often used as shaving mirrors to see a larger image of the face. The dentists use concave mirrors to see large images of the teeth of patients. Large concave mirrors are used to concentrate sunlight to produce heat in solar furnaces

10.5.2 Ray Diagrams for a Convex Mirror

In case, of a convex mirror, there are only two possible positions (Fig 10.9 to 10.10) where the object can be positioned and an image can be formed.

a. Object is positioned at Infinity

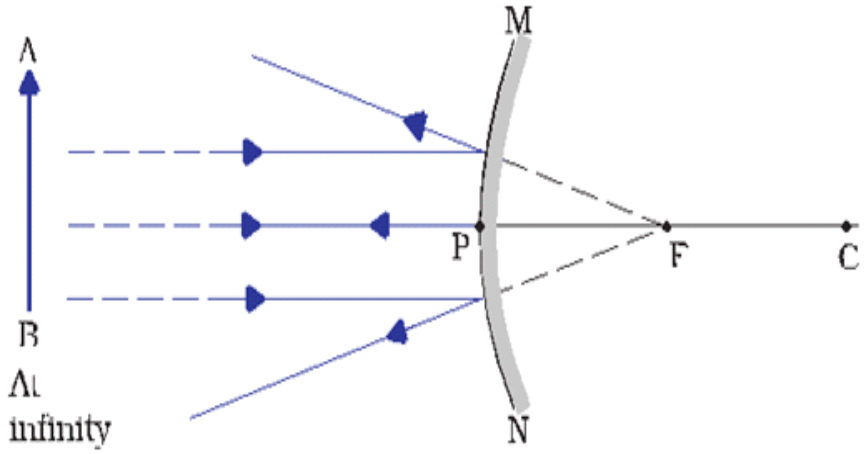


Figure 10.9: **Object is positioned at infinity**

When the object is at infinity, the rays that are parallel to the principal axis are divergent after getting reflected from the convex mirror. The diverged rays are extended behind the mirror, where they intersect each other at the principal focus (F). Hence, in this case, the properties of the images formed are formed at the principal focus (F) behind the mirror and are highly diminished, the images are virtual and erect.

b. Object is positioned between the Pole (P) and Infinity

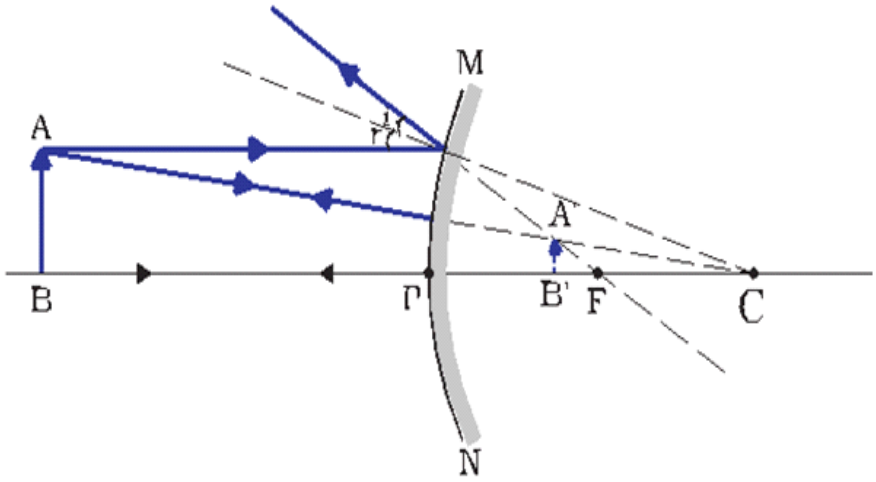


Figure 10.10: **Object is positioned between the pole (P) and infinity**

When the object AB is placed between pole (P) and infinity, a ray AYthat starts from point A of the object AB that's running parallel to the principal axis is reflected. On extending behind the mirror, FY appears to come from principal focus (F) and another ray from point A of the object AB that goes towards the center of curvature is reflected along AC. The two rays, AC and FY are diverging rays and when extended behind the mirror, they appear to intersect each other at point At.

Therefore, the properties of the images formed here are formed behind the mirror, between the pole and infinity, the images are diminished and are virtual and erect.

Table 2

Nature, position and relative size of the image formed by a convex mirror

Position of the Object	Position of the Image	Size of the Image	Nature of the Image
At Infinity	At the focus of F, behind the mirror	High diminished, Point-sized	Virtual and erect
Between infinity and the pole P of the mirror	Between P and F, behind the mirror	Diminished	Virtual and erect

Uses of convex mirrors

Convex mirrors are commonly used as rear-view (wing) mirrors in vehicles. These mirrors are fitted on the sides of the vehicle, enabling the driver to see traffic behind him/her to facilitate safe driving. Convex mirrors are preferred because they always give an erect, though diminished, image. Also, they have a wider field of view as they are curved outwards. Thus, convex mirrors enable the driver to view much larger area than would be possible with a plane mirror.

Check Your Progress-2

Note: (a) Answer the questions given below.

(b) Compare your answers with those given at the end of this lesson.

1. Fill in the blanks:

(a) If the object is placed between infinity and center of curvature (C) of a concave mirror, then the image formation is between_____.

(b) When the object is positioned at infinity in case of convex mirror, the image formed is_____.

(c) When the object MN is placed at the center of curvature (C) of a concave mirror, the image formed is _____.

(d) If the position of the object is at infinity, the nature of the image on case of concave is _____.

2. State True/False:

(A) The dentists use concave mirrors to see large images of the teeth of patients. patients. ( )

(B) Concave mirrors are commonly used as rear-view mirrors in vehicles. ( )

(C) Convex mirrors are preferred to be used as rear-view mirrors because they always give an erect, though diminished, image. ( )

3. Choose the correct option for the following question:

Q. No matter how far you stand from a mirror, your image appears erect. The mirror is likely to be

(a) plane

(b) concave

(c) convex

(d) either plane or convex.

10.6 LET US SUM UP

- Light seems to travel in straight lines.
- Mirrors and lenses form images of objects. Images can be either real or virtual, depending on the position of the object.
- The reflecting surfaces, of all types, obey the laws of reflection.
- The focal length of a spherical mirror is equal to half its radius of curvature.
- Concave mirrors are commonly used in torches, search-lights and vehicles headlights to get powerful parallel beams of light.
- Convex mirrors are commonly used as rear-view (wing) mirrors in vehicles.

10.7 LESSON END EXERCISE

Q. 1. Draw neat and clean ray diagrams for concave and convex mirrors.

Q. 2. What are the uses of concave and convex mirrors?

Q. 3. What are the properties of properties of the images formed by concave and convex mirrors when object is placed at different positions?

10.8 SUGGESTED FURTHER READINGS

Reflection and Refraction (2020). Chapter 10 from NCERT Class 10th Science Book.

https://www.toppr.com/guides/physics/light-reflection-and-refraction/image-formation-by-spherical-mirrors/

https://www.learncbse.in/ncert-solutions-for-class-8-science-light/

10.9 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress-1

Q. 1.

(a) concave mirror

(b) convex mirror

(c) aperture

(d) 5 cm

Q. 2.

A. (b) pole

B. (a) midway between the pole and centre of curvature

Check Your Progress-2

Q. 1.

(a) between principal focus (F) and center of curvature (C)

(b) virtual and erect

(c) real and inverted

(d) real and inverted

Q.2.

(a) True

(b) False

(c) True

Q. 3.

(c) Conve

Lesson No. : 11 **Unit : IV**

REFRACTION

Structure

11.1 INTRODUCTION

Dear students, you might have observed while traveling on a road on a hot summer day, distantly, water appears in the middle of the road out of no-where. Also if there is only one fish in the aquarium, still it appears to be many. Do you know how this happens? This

is all due to the refraction. Let us study more about refraction, laws of refraction, dispersion and scattering of light.

11.2 OBJECTIVES

After going through this lesson, you shall be able to:

- describe the concept of refraction,
- generalise the laws of refraction,
- demonstrate the concept of refractive index,
- explain refraction of light through a prism, and
- describe the concepts of dispersion and scattering of light.

11.3 REFRACTION

The change in direction or bending of a light wave passing from one transparent medium to another; caused by the change in wave's speed is known as "Refraction".

Another example of refraction is if you take a pencil/stick and dip it in water (Fig 11.1), the pencil/stick appears to be bent. It does not appear straight. Why is the pencil/stick appearing bent even though it is a straight nice pencil/stick? This is because of a phenomenon of refraction. The medium involved here is air and water. As soon as the light waves enter the water, the light rays bend and because of this bending of light waves, we see the pencil/stick as broken.

***Fig 11.1*: Straight stick appears to be bent when partly immersed in water**

Atmospheric Refraction

When the refraction of light takes place due to earth's atmosphere it is called *atmospheric refraction*. So, when light ray enter the atmosphere there is air and every air layer has different temperature. These air layers have different optical densities. Cooler air layer is an optically denser medium for light rays whereas warmer air layer is optically rarer medium for light rays.

The following are the examples of atmospheric refraction of light.

(1) Twinkling of stars

Stars twinkle at night because their light is refracted in the atmosphere. When the light of star enters the earth's atmosphere it undergoes refraction due to different optical densities of the air. Therefore, stars appear bright at one moment and dim in another.

(2) Stars appear higher than they are

The light from stars is refracted as it comes down into earth's atmosphere. The air higher up in the sky is rarer and near the earth's surface is denser. As the star light falls down the dense air bends it more and thus stars appear higher than they actually are.

(3) Advance sunrise and delayed sunset

It is due to refraction of light that we are able to see the sun two minutes before sunrise and two minutes after actual sunset. At the time of sunrise the sunlight is coming from less dense air to more dense air. In this case the sunlight is refracted downwards and because of this sun appears to be raised above the horizon than it actually is.

11.4 LAWS OF REFRACTION

The following are the laws of refraction of light:

(i) The incident ray, the refracted ray and the normal to the interface of two transparent media at the point of incidence, all lie in the same plane.

(ii) The ratio of sine of angle of incidence to the sine of angle of refraction is a constant, for the light of a given colour and for the given pair of media. This law is also known as Snell's law of refraction.

If *i* is the angle of incidence and *r* is the angle of refraction, then,

$$\frac{\sin i}{\sin r} = \text{constant}$$

The ratio of the sine of the angle of incidence and sine of the angle of refraction is constant. This constant value is called the refractive index of the second medium with respect to the first.

Check Your Progress-1

Note: (a) Answer the questions given below.

(b) Compare your answers with those given at the end of this lesson.

1. Fill in the blanks:

(a) The change in direction or bending of a light wave passing from one transparent medium to another; caused by the change in wave's speed is known as _____.

(b) Straight stick appears to be _____ when partly immersed in water.

(c) The incident ray, the refracted ray and the normal to the interface of two transparent media at the point of incidence, all lie in the _____.

(d) The ratio of sine of angle of incidence to the sine of angle of refraction is a constant, for the light of a given colour and forthe given pair of media. This law is also known as _____.

11.5 REFRACTIVE INDEX

The extent of bending of light rays entering from one medium to another is the "Refractive Index". It is denoted by the letter 'n'. It is represented as:

$$n = c/v$$

where c = velocity/speed of light of a certain wavelength in the air and v = velocity of light in any medium.

The refractive index can be linked to an important physical quantity, the relative speed of propagation of light in different media. It turns out that light propagates with different speeds in different media. Light travels the fastest in vacuum with the highest speed of 3×10^8 m s^{-1}. In air, the speed of light is only marginally less, compared to that in vacuum. It reduces considerably in glass or water. The value of the refractive index for a given pair of media depends upon the speed of light in the two media, as given below.

Consider a ray of light travelling from medium 1 into medium 2, as shown in Fig.11.2. Let v_1 be the speed of light in medium 1 and v_2 be the speed of light in medium 2. The refractive index of medium 2 with respect to medium 1 is given by the ratio of the speed of light in medium 1 and the speed of light in medium 2. This is usually represented by the symbol n_{21}. This can be expressed in an equation form as

$$n_{21} = \frac{\text{Speed of light in medium 1}}{\text{Speed of light in medium 2}} = \frac{v_1}{v_2}$$

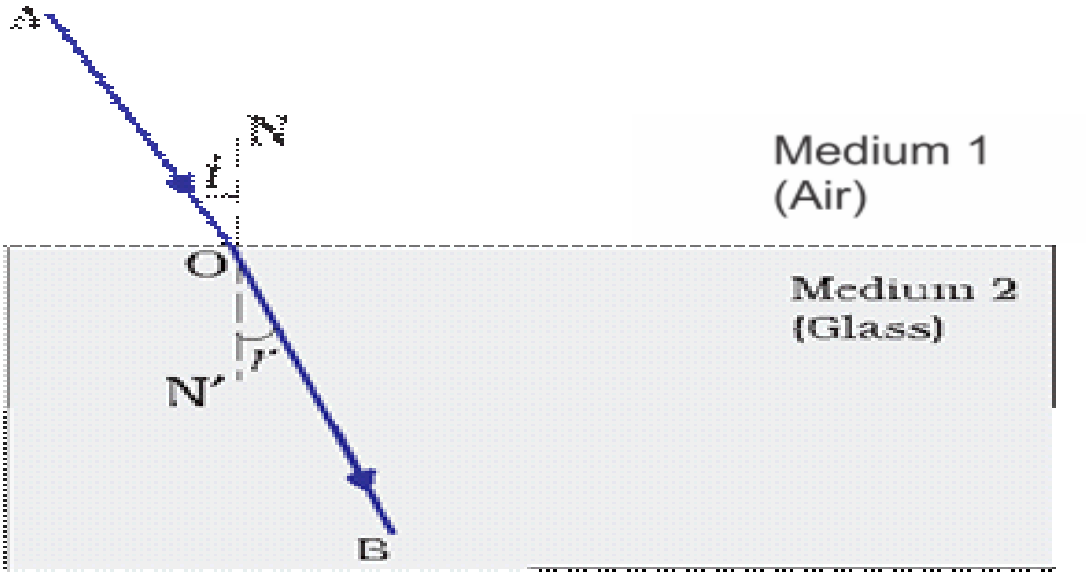


*Figure 11.2:*Refraction of light when it enters from air to glass

By the same argument, the refractive index of medium 1 with respect to medium 2 is represented as n_{12}. It is given by

$$n_{21} = \frac{\text{Speed of light in medium 2}}{\text{Speed of light in medium 1}} = \frac{\upsilon_1}{\upsilon_2}$$

If medium 1 is vacuum or air, then the refractive index of medium 2 is considered with respect to vacuum. This is called the absolute refractive index of the medium. It is simply represented as n_2. If c is the speed of light in air and v is the speed of light in the medium, then, the refractive index of the medium n_m is given by

$$n_m = \frac{\text{Speed of light in air}}{\text{Speed of light in the medium}} = \frac{c}{\upsilon}$$

The absolute refractive index of a medium is simply called its refractive index. The refractive index of several media is given in Table 11.1. From the Table you can know that the refractive index of water, n_w = 1.33. This means that the ratio of the speed of light in air and the speed of light in water is equal to 1.33. Similarly, the refractive index of crown glass, n_g =1.52. Such data are helpful in many places.

Table 11.1 Refractive Index of Several Media

Material	Refractive Index	Material	Refractive Index
Air	1.0003	Crown glass	1.52
Ice	1.31	Canada Balsam	1.53
Water	1.33	Rock salt	1.54
Alcohol	1.36	Carbon disulphide	1.63
Kerosene	1.44	Dense flint glass	1.65
Fused quartz	1.46	Ruby	1.71
Turoentine oil	1.47	Sapphire	1.77
Benzene	1.50	Diamond	2.42

Check Your Progress-2

Note: (a) Answer the questions given below.

(b) Compare your answers with those given at the end of this lesson.

1. Fill in the blanks:

(a) The extent of bending of light rays entering from one medium to another is the _____.

(b) Refractive Index is denoted by the letter _____.

(c) The value of the refractive index for a given pair of media depends upon the _____.

(d) The refractive index of medium 2 with respect to medium 1 is given by the ratio of the speed of light in _____ and the speed of light in _____.

(e) The refractive index of medium 2 with respect to medium 1 is represented by _____.

2. State True/False:

(a) If medium 1 is vacuum or air, then the refractive index of medium 2 is considered with respect to vacuum. This is called the absolute refractive index of the medium. ( )

(b) The absolute refractive index of a medium is simply called its refractive index. ( )

11.6 REFRACTION OF LIGHT THROUGH A PRISM

A glass prism is a transparent object having two triangular ends and three rectangular sides. The refraction of light in glass prism is different from a glass slab. This is because in glass prism, the incident ray of light is not parallel to emergent ray of light.

When a ray of light enters the glass prism it gets deviated two times. First when it enters the glass prism and second when it comes out of the prism. This is because the refracting surfaces of the prism are not parallel to each other. Also, when the ray of light passes through the prism it bends towards its base.

- If you take a glass prism, you can see that it has 2 triangular bases and three rectangular lateral surfaces, inclined at an angle. This angle is called the angle of the prism.
- Let's look at a top view of a triangular prism with a ray of light entering it.

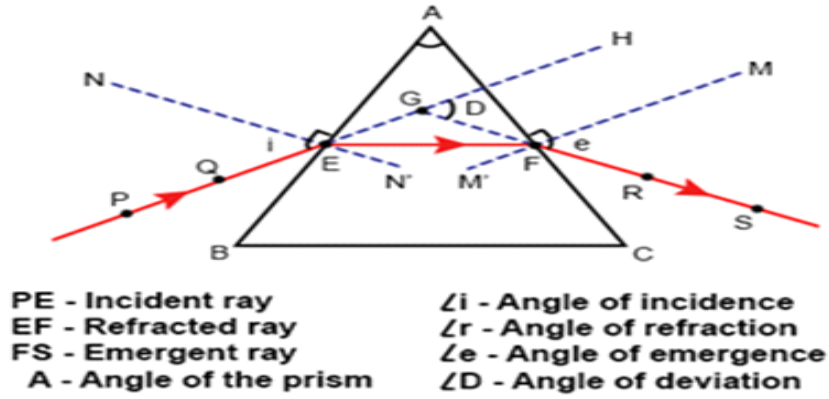


Figure 11.3: Refraction of light through prism

In the figure 11.3, A is the angle of the prism.

- As per Snell's law, light traveling from a rarer medium to a denser medium bends towards the normal, and vice versa. Glass is denser than air, and thus, when a ray of light falls on the surface of the prism, it bends towards the normal. According to the diagram, ray PE falls on the surface of the prism and bends towards the normal NE.
- Then, while moving from the glass to air, the emergent ray FS bends away from the normal.
- "HDS is the angle of deviation which tells us how much the emergent ray has deviated from the incident ray. When the angle of incidence is equal to the angle of emergence, the angle of deviation is minimum.
- According to the figure, "PEN" = "MES" and "HDS" is thus the angle of minimum deviation. The refracted ray EF is parallel to side BC in this case.

This is how a ray of white light scatters into seven colours when it passes through a prism. The different colors of light wave experience a different degree of deviation and thus white light splits into its components when it is subjected to refraction.

11.7 DISPERSION AND SCATTERING OF LIGHT

Dispersion of light

In 1665, Isaac Newton discovered that white light consists of seven colours. He found that if a beam of white light is passed through glass prism then it will split in to seven colours. These colours are violet, indigo, blue, green, yellow, orange and red (VIBGYOR).The band of seven colours formed when a beam of white light is passes through a glass prism is called spectrum of white light. The splitting of white light into seven colours on passing through a transparent medium is called dispersion of light.

The dispersion of white light happens because the angle of refraction of lights of different colours is different while passing through the transparent medium. For example, red colour deviates least and is formed at the upper part of the spectrum and violet colour is deviated maximum and is formed at the bottom of the spectrum (Figure 11.4).

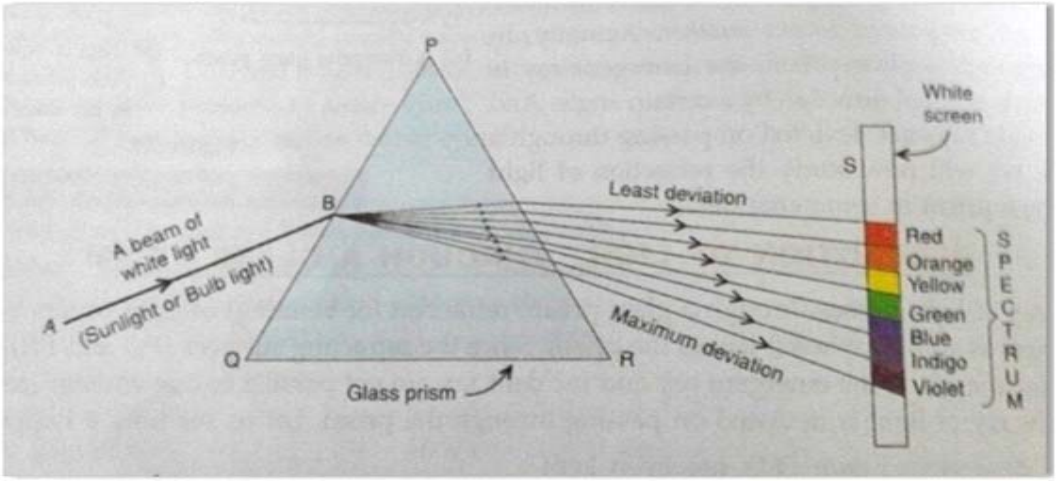


Figure 11.4: Dispersion of light

It is the phenomenon in which white light splits into its constituent colours. White light contains several constituents that vary in their wavelengths (it contains the light of different colours). Since the wavelengths of these constituents are different, their speeds differ from each other in a medium. Note that their speed in a vacuum is the same. In a material medium, the speed of different wavelengths is different.

Rainbow is formed when it is raining at the time of sunshine. When the white sunlight falls on the raindrops and leaves them, then the white light is refracted and an arc of seven colours is formed in the sky. In this situation, tiny raindrops act as glass prism splitting the white sunlight.

Scattering of Light

Scattering of light can be defined as the deviation of light rays from their straight trajectory. As light propagates through the atmosphere, it travels in a straight path until comes under obstruction from the gas molecules and dust particles in the atmosphere. The process in which light gets deflected by the tiny particles in the medium through which the light passes is called scattering.

Here the light is not split into its constituent colours. Rather, the incident beam of light just gets redirected after being struck by the atmospheric particles. The blue colour of the sky is due to the scattering of sunlight by the molecules of air. During sunset, sunlight has to travel a greater distance, so shorter wavelengths get scattered off and removed and only red wavelengths reach us.

When light is scattered due to particles in its path, it is called Tyndall effect. The way a beam of sunlight becomes visible when it passes through dust particles in a room, when sunlight passes through a canopy of dense forest etc., are examples of Tyndall effect.

In 1859, Tyndall discovered that when white light is passed through clear liquid having small suspended particles, then the blue colour of white light has shorter wavelength and is scattered more than the red colour that has longer wavelength.

- The colour of scattered light depends on the size of particles
- It is due to the scattered large dust particles and water droplets in the atmosphere that when white sunlight falls on them it is reflected in such a way that the scattered light also appears white. Dust particles and water droplets in the atmosphere are larger than the wavelength range of the visible light.
- The extremely small air molecules in the atmosphere scatter mainly blue light when white sunlight falls on them. This is because blue colour has lower wavelength and is much more by the air molecules.

Why the sky is blue?

When white sunlight falls in the atmosphere, lights with longer wavelength are not scattered by the air molecules. It is only the blue light which has shorter wavelength that is scattered most by the air molecules in the atmosphere. This is why the sky looks blue.

Why the Sun appears red at sunrise and sunset?

At the time of sun rise and sunset all the blue coloured light is scattered out and is away from our sight. So the light reaching us mainly at the time of sunrise and sunset is red which has longer wavelength.

Check Your Progress-3

Note: (a) Answer the questions given below.

(b) Compare your answers with those given at the end of this lesson.

1. Fill in the blanks:

(a) A glass prism is a transparent object having _____ triangular ends and _____ rectangular sides.

(b) _____ is the phenomenon in which white light splits into its constituent colours.

(c) Dispersion of light in a prism results in the formation of a _____.

(d) When light is scattered due to particles in its path, it is called _____.

11.8 LET US SUM UP

- The refracting surfaces obey the laws of refraction.
- A light ray travelling obliquely from a denser medium to a rarer medium bends away from the normal. A light ray bends towards the normal when it travels obliquely from a rarer to a denser medium.
- Light travels in vacuum with an enormous speed of 3×10^8 m s^{-1}. The speed of light is different in different media.
- The refractive index of a transparent medium is the ratio of the speed of light in vacuum to that in the medium.
- In case of a rectangular glass slab, the refraction takes place at both air-glass interface and glass-air interface. The emergent ray is parallel to the direction of incident ray.
- Refraction is the cause for a lot more phenomena.
- When you look at a straw dipped in a glass of water, the part in the air and the part in water look like they are not the same straw! It looks distorted.
- Sometimes, in a desert, travelers see water or trees on the ground, when there is actually nothing there. This phenomena is known as ‘mirage’.
- Some other natural phenomena that also occur because of refraction, such as the twinkling of stars and the formation of rainbows.
- When a beam of white light passes through a medium, the material medium splits the white light into different components. This phenomenon is called dispersion. When white light passes through

a prism, it disperses into a band of seven different colours. This band of colours obtained from the dispersion of light is called a spectrum.

11.9 LESSON END EXERCISE

Q. 1. Explain the concept of refraction and refractive index.

Q.2. Draw a well labelled diagram showing refraction of light through prism.

Q. 3. What do you mean by dispersion?

Q. 4. Write a note on scattering of light.

11.10 SUGGESTED FURTHER READINGS

Dispersion (2020). https://www.britannica.com/science/dispersion-physics

Refraction (2020). https://www.toppr.com/content/concept/laws-of-refraction-210214/

Reflection and Refraction (2019). Chapter 10 from NCERT Class 10th Science Book.

Refraction of Light through a Glass Prism. https://byjus.com/physics/refraction-light-glass-prism/

11.11 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress-1

Q. 1.

a. Refraction

b. Bent

c. same plane

d. Snell's law of refraction

Check Your Progress-2

Q. 1.

a. Refractive Index

b. n

c. speed of light in the two media

d. medium 1, medium 2

e. n_{21}

Q. 2.

a. True

b. True

Check Your Progress-3

a. two, three

b. Dispersion

c. Spectrum

d. Tyndall effect

_____

Lesson No. : 12 **Unit : IV**

METALS AND NON - METALS

Structure

12.1 INTRODUCTION

Dear students, the materials present around us are grouped widely into metals and non-metals. So, it is important to know whether a particular element is a metal or

non-metal. This lesson shall cover the properties of metals and non-metals and enable you to differentiate between metals and non-metals. The concept and prevention of corrosion have also been discussed.

12.2 OBJECTIVES

After going through this lesson, you shall be able to:

- explain the physical and chemical properties of metals,
- describe the physical and chemical properties of non-metals,
- differentiate between metals and non-metals, and
- explain the concept and prevention of corrosion.

12.3 METALS

Metals, as chemical elements, comprise 25% of earth's crust and are present in many aspects of modern life. The history of refined metals is thought to begin with the use of copper about 11,000 years ago. Gold, silver, iron, lead, and brass were likewise in use before the first known appearance of bronze in the 5th millennium BCE.

12.3.1 Physical Properties

The physical properties of metals are:

Luster

The metals in their pure state usually shine. This property of metals is called luster. The shine on the metallic surface is the metallic luster. They shine in light due to the reason that the metals possess free electrons that vibrate on getting in contact with light.

Malleability

Malleability refers to the property of metals by which they can be beaten into thin sheets. Gold and silver are the most malleable metals. One such example is silver foil made from beaten silver metal for decorating sweets.

Ductility

The ability of metals to be drawn into thin wires is called ductility. Gold is

the most ductile metal. You will be surprised to know that a wire of about 2 km length can be drawn from one gram of gold.

Conductivity

The metals are a good conductor of heat and electricity as they can pass through them. They are good conductors of heat and electricity. The best conductors of electricity are silver and copper, however, lead and mercury are poor conductors of electricity.

High melting point

Metals have high melting point except Caesium and Galium have the very low melting point.

Sonorous

On being struck hard, the metals produce a ringing sound. Due to this property, they sonorous. For example- the school bell produces a loud ringing sound when struck with hammer hard. Some examples are- Iron, Gold, Copper, Aluminium, Magnesium, and many more.

Solid

Except for mercury, all the metals are solid. Mercury is in the liquid state at room temperature. The exceptional metals are Sodium (Na), Potassium (K) and Mercury (Hg). The metals like Sodium (Na) and Potassium(K) are easily cut with the help of a knife. Other examples of metals are iron, copper, silver, aluminium, calcium, gold etc.

12.3.2 Chemical Properties

The chemical properties of metal are:

Reaction with Oxygen (Oxidation)

All metals except the noble metals, which is gold and silver react with the oxygen to form basic oxides. In the reaction, the metal reacts vigorously with oxygen and generates a lot of heat. The reaction has been given below:

Magnesium (Mg) + Oxygen (O_2) $\longrightarrow$ 2MgO (Magnesium Oxide)

Rusting of Iron

Iron (Fe) + Oxygen (O_2) + Water (H_2O) $\longrightarrow$ Fe_2O_3(Iron Oxide, is brown colour rust)

Greenish Deposit on the Surface of Copper Vessels

The dull greenish material that is deposited on the surface of copper is a mixture of copper hydro oxide [$Cu(OH)_2$] and copper carbonate ($CuCO_3$) which takes place as –

$$2Cu + H_2O + CO_2 + O_2 \longrightarrow [Cu(OH)_2] + (CuCO_3)$$

We have learnt that metal oxides are basic in nature (turn red litmus blue). But some metal oxides, such as aluminium oxide, zinc oxide, etc., show both acidic as well as basic behaviour. Such metal oxides which react with both acids as well as bases to produce salts and water are known as amphoteric oxides. Aluminium oxide reacts in the following manner with acids and bases –

$$Al_2O_3 + 6HCl \longrightarrow 2AlCl_3 + 3H_2O$$

$$Al_2O_3 + 2NaOH \longrightarrow 2NaAlO_2 + H_2O$$

(Sodium aluminate)

Most metal oxides are insoluble in water but some of these dissolve in water to form alkalis. Sodium oxide and potassium oxide dissolve in water to produce alkalis as follows –

$$Na_2O(s) + H_2O(l) \longrightarrow 2NaOH(aq)$$

$$K_2O(s) + H_2O(l) \longrightarrow 2KOH(aq)$$

All metals do not react with oxygen at the same rate. Different metals show different reactivities towards oxygen. Metals such as potassium and sodium react so vigorously that they catch fire if kept in the open. Hence, to protect them and to prevent accidental fires, they are kept immersed in kerosene oil. At ordinary temperature, the surfaces of metals such as magnesium, aluminium, zinc, lead, etc., are covered with a thin layer of oxide. The protective oxide layer prevents the metal from further oxidation. Iron does not burn on heating but iron filings burn vigorously

when sprinkled in the flame of the burner. Copper does not burn, but the hot metal is coated with a black coloured layer of copper(II) oxide. Silver and gold do not react with oxygen even at high temperatures.

Reaction with Water (Hydrolysis)

Metals react with water and produce a metal oxide and hydrogen gas. Metal oxides that are soluble in water dissolve in it to further form metal hydroxide. But all metals do not react with water.

Metal + Water $\longrightarrow$ Metal oxide + Hydrogen

Metal oxide + Water $\longrightarrow$ Metal hydroxide

Metals like potassium and sodium react violently with cold water. In case of sodium and potassium, the reaction is so violent and exothermic that the evolved hydrogen immediately catches fire.

$2K(s) + 2H_2O(l) \longrightarrow 2KOH(aq) + H_2(g) + \text{heat energy}$

$2Na(s) + 2H_2O(l) \longrightarrow 2NaOH(aq) + H_2(g) + \text{heat energy}$

The reaction of calcium with water is less violent. The heat evolved is not sufficient for the hydrogen to catch fire.

$Ca(s) + 2H_2O(l) \longrightarrow Ca(OH)_2(aq) + H_2(g)$

Calcium starts floating because the bubbles of hydrogen gas formed stick to the surface of the metal.

Magnesium does not react with cold water. It reacts with hot water to form magnesium hydroxide and hydrogen. It also starts floating due to the bubbles of hydrogen gas sticking to its surface.

Metals like aluminium, iron and zinc do not react either with cold or hot water. But they react with steam to form the metal oxide and hydrogen.

$2Al(s) + 3H_2O(g) \longrightarrow Al_2O_3(s) + 3H_2(g)$

$3Fe(s) + 4H_2O(g) \longrightarrow Fe_3O_4(s) + 4H_2(g)$

Metals such as lead, copper, silver and gold do not react with water at all.

Reaction with Acids (Acidity)

Metals react with acids to give a salt and hydrogen gas (burns with a 'pop' sound).

Metal + Dilute acid $\longrightarrow$ Salt + Hydrogen

Zinc + Hydrochloric acid $\longrightarrow$ Zinc chloride + Hydrogen

$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$

$Zn + H_2SO_4 \longrightarrow ZnSO_{4+}H_2$

Hydrogen gas is not evolved when a metal reacts with nitric acid. It is because HNO_3 is a strong oxidising agent. It oxidises the H_2 produced to water and itself gets reduced to any of the nitrogen oxides (N_2O, NO, NO_2). But magnesium (Mg) and manganese (Mn) react with very dilute HNO_3 to evolve H_2 gas.

Aqua regia, (Latin for 'royal water') is a freshly prepared mixture of concentrated hydrochloric acid and concentrated nitric acid in the ratio of 3:1. It can dissolve gold, even though neither of these acids can do so alone. Aqua regia is a highly corrosive, fuming liquid. It is one of the few reagents that is able to dissolve gold and platinum.

Reaction with Solutions of other Metal Salts

Reactive metals can displace less reactive metals from their compounds in solution or molten form.

As we know that all metals are not equally reactive. If metal A displaces metal B from its solution, it is more reactive than B.

Metal A + Salt solution of B $\longrightarrow$ Salt solution of A + Metal B

In the reaction between copper sulphate ($CuSO_4$) and zinc (Zn), zinc (Zn) replaces copper (Cu) from copper sulphate (CuSO4). That is why the blue colour of copper sulphate disappears and a powdery red mass of copper is deposited at the bottom of the beaker. The reaction can be represented as follows:

Copper Sulphate ($CuSO_4$) + Zinc (Zn) $\longrightarrow$ Zinc Sulphate ($ZnSO_4$) + Copper (Cu)

(Blue) (Colourless) (Red)

But here is another reaction:

Zinc Sulphate ($ZnSO_4$) + Copper turnings (Cu) ⟶ No displacement.

In this reaction, copper is less reactive than zinc, so it cannot replace zinc from its salt zinc sulphate. A more reactive metal can replace a less reactive metal, but a less reactive one cannot replace a more reactive metal.

The Reactivity Series

The reactivity series is a list of metals arranged in the order of their decreasing activities. After performing displacement experiments, the following series, known as the reactivity or activity series has been developed.

K > N a > C a > Mg > Al > Zn > Fe > Pb > H > Cu > Hg > Ag > Au

Most reactive ⟶ Least reactive

Reactivity Decreases

Uses of Metals

- Metals are used to make tools because they can be strong and easy to shape. Iron and steel have been used to make bridges, buildings, or ships.
- Some metals are used to make items like coins because they are hard and will not wear away quickly. Some metals, like steel, can be made sharp and stay sharp, so they can be used to make knives, axes or razors.
- Rare metals with high value, like gold, silver and platinum are often used to make jewellery. Metals are also used to make fasteners and screws.
- Pots used for cooking can be made from copper, aluminium, steel or iron.
- Lead is very heavy and dense and can be used as ballast in boats to stop them from turning over, or to protect people from ionizing radiation.

Check Your Progress-1

Note: (a) Answer the questions given below.

(b) Compare your answers with those given at the end of this lesson.

1. Which of the following can be beaten into thin sheets?

(A) Zinc (b) Phosphorus (c) Sulphur (d) Oxygen

2. Which of the following statements is correct?

(a) Sodium is a very reactive metal. ( )

(b) Copper displaces zinc from zinc sulphate solution. ( )

(c) Generally, metals are not ductile. ( )

(d) Metals are not malleable. ( )

3. Fill in the blanks.

(a) Metals are conductors of heat and _____.

(b) Iron is _____ reactive than copper.

(c) Metals react with acids to produce _____ gas.

12.4 NON-METALS

Non-metals are materials not holding the characteristics of metals, means they are not shiny, hard, fusible, malleable, ductile, etc. Many materials like coal and sulphur are very soft and dull in appearance. They break down into very fine thin powdery mass on tapping with the hammer. They are neither in – sonorous and also are a very poor conductor of heat and electricity. In the periodic table non-metals are kept almost in the right most. In modern periodic table there are 22 non-metals in which there are 11 gases, 1 liquid and 10 solid. Bromine occurs in the state of liquid and hydrogen, nitrogen, oxygen, chlorine etc are found in gaseous forms. But carbon, sulphur, phosphorous, iodine etc solid non-metals.

12.4.1 Physical Properties

The physical properties of non-metals are:

The solid non-metals are brittle or dull and soft as they can be broken down into a powdery substance or mass on tapping down with the hammer. Few examples are Coal and Sulphur. However, Diamond is an exception as it is the hardest non-metal.

- Non – metals may be either solids, liquids, or gases.
- Non-metals are poor conductors of heat and electricity except Graphite.
- They do not possess metallic luster.
- Non-metals are not sonorous, they do not produce a ringing sound.
- Non-metals possess no malleability.
- They are not ductile.
- They have dull luster, however, iodine is lustrous.

Some example of non – metals are carbon, oxygen, sulphur, phosphorous, and many more.

12.4.2 Chemical Properties of Non-Metals

Reaction with Oxygen (Oxidation)

Generally, oxides of non-metals are acidic in nature.

Sulphur dioxide gasis formed in the reaction of sulphur and oxygen. When sulphur dioxide is dissolved in water sulphurous acid is formed. The reaction can be given as follows: Sulphur dioxide (SO_2) + Water (H_2O) '! Sulphurous acid (H_2SO_3) The sulphurous acid turns blue litmus paper red.

Reaction with Water (Hydrolysis)

Most non-metals produce acidic oxides when dissolved in water. Other non-metals do not react with water though they may be very reactive in air. Such non-metals are stored in water. For example, phosphorus is a very reactive non-metal. It catches fire if exposed to air. To prevent the contact of phosphorus with atmospheric oxygen, it is stored in water.

Reaction with Acids (Acidity)

Non-metals generally do not react with acids.

Reaction with Bases

Non-metals generally do not react with bases.

Uses of Non Metals

- Many non-metals like chlorine, sulphur, iodine are very useful for medicinal purposes.
- Non-metal like oxygen is very essential for our life for respiration.
- We use nitrogen phosphorus in fertilizers for better plant growth and enhance the fertility of the soil.
- Non-metal like sulphur is used in crackers.
- Chlorine and fluorine are useful for the water purification purpose.

Check Your Progress-2

Note: (a) Answer the questions given below.

(b) Compare your answers with those given at the end of this lesson.

1. Most non-metals produce _____ oxides when dissolved in water.

   (a) Basic

   (b) Acidic

   (c) Neutral Compounds

   (d) None of the above.

2. Mark 'T' if the statement is true and 'F' if it is false:

   (a) Generally, non-metals react with acids. ( )

   (b) All non-metals are ductile. ( )

   (c) Phosphorus is a very reactive non-metal. ( )

   (d) Coal can be drawn into wires. ( )

12.5 DIFFERENCE BETWEEN METALS AND NON-METALS

Metals	Non-Metals
1. Metals are lustrous.	1. Non-metals have no lustre. Exception: Iodine is a non-metal but it is lustrous.
2. Generally, metals are malleable and ductile.	2. Non-metals are not malleable and ductile.
3. Generally, metals are good conductors of heat and electricity.	3. Non-metals are poor conductors of heat and electricity. Exception: Graphite, an allotrope of carbon, is a conductor of electricity.
4. On burning, metals react with oxygen to produce metal oxides which are basic in nature.	4. Non-metals react with oxygen to produce non- metallic oxides which are acidic in nature.
5. Some metals react with water to produce metal hydroxides and hydrogen gas.	5. Generally, non-metals do not react with water.
6. Metals react with acids and produce metal salts and hydrogen gas.	6. Generally, oxides of non-metals are acidic in nature.
7. Some metals react with bases to produce hydrogen gas.	7. Non-metals generally do not react with bases.
8. Metals have high melting points but gallium and caesium have very low melting points.	8. Non-metals tend to have comparatively low boiling and melting points. Exception: Diamond, an allotrope of carbon, has a very high melting and boiling point.
9. All metals except mercury exist as solids at room temperature.	9. The non-metals are either solids or gases except bromine which is a liquid.
10. Metals are generally hard. Exception: Alkali metals (lithium, sodium, potassium) are so soft that they can be cut with a knife.	10. Diamond, an allotrope of carbon, is the hardest natural substance known.

12.6 CORROSION AND ITS PREVENTION

Corrosion is a process where the metal corrodes. When a metal is attacked by substances around it such as moisture, acids, etc., it is said to corrode and this process is called corrosion. It is a process where the water or the moisture on the surface of the metal oxidizes with the atmospheric oxygen, it is an oxidation reaction. The black coating on silver and the green coating on copper are other examples of corrosion. Corrosion causes damage to construction, bridges, car bodies, bridges, iron railings, ships and to all objects made of metals, especially those of iron. Corrosion of iron is a serious problem. Every year an enormous amount of money is spent to replace damaged iron. Aluminum is also an important structural metal, but even aluminum goes under oxidation reactions. However, aluminum doesn't corrode or oxidize as rapidly as its reactivity suggests. An alloy of aluminum or any other metal like magnesium can make aluminum stronger, stiffer and harder.

The alkali metals like sodium need to be stored in oil as they corrode quickly. Less reactive metals like lead and copper are used to roof situations. Copper (Cu) corrodes and forms a basic green carbonate and lead corrodes to form a white lead oxide or carbonate.

Silver articles become black after some time when exposed to air. This is because it reacts with sulphur in the air to form a coating of silver sulphide.

Copper reacts with moist carbon dioxide in the air and slowly loses its shiny brown surface and gains a green coat. This green substance is copper carbonate.

Iron when exposed to moist air for a long time acquires a coating of a brown flaky substance called rust.

The iron pillar near the Qutub Minar in Delhi did not get rust though it was built more than 1600 years ago by the iron workers of India. They had developed a process which prevented iron from rusting.

Prevention of Corrosion

Covering the surface of the metal with enamel and lacquers helps to protect the metal against corrosion, parts of machines that move can be protected by coating layers of water repellent oil or grease. Another way of protecting iron and steel is by

painting on them as it creates a barrier between the surface of the metal and moist air or water. Whereas, the other methods of protecting a metal are alloying, galvanizing, electroplating, etc.

Alloying

An alloy is a mixture of two or more metals. Alloying is a process where metals like iron or steel are mixed with a less reactive metal like chromium, magnesium, etc for protection against corrosion and to create non-rusting alloys. For e.g. Brass is an alloy which consists of copper is a cheap and non – reactive alloy. Another example of a non-rusting alloy is stainless steel, a mixture of iron and carbon.

Galvanizing

Coating iron or steel with Zinc to prevent corrosion is known as galvanizing. Dipping iron or steel in a liquid form of zinc and using it as the negative cathode zinc is coated on it, the layer is produced by electrolytic deposition. Zinc oxides or corrodes to create a zinc oxide layer that does not flake off like iron oxide rust.

Electroplating

Electroplating is a process where a metal is coated by electrolytic deposition with chromium, silver, or another metal. This process is generally held at room temperature from aqueous electrolytes. It is one of the most popular and common methods to prevent corrosion.

Check Your Progress-3

Note: (a) Answer the questions given below.

(b) Compare your answers with those given at the end of this lesson.

1. The surface of some metals, such as iron, is corroded when they are exposed to _____ for a long period of time.

   (a) moist air

   (b) oil

   (c) grease

   (d) paint

2. Which of the following metals corrodes quickly?

   (a) Gold (Au)

   (b) Silver (Ag)

   (c) Copper (Cu)

   (d) Iron (Fe)

3. Which of the following methods is suitable for preventing an iron frying pan from rusting?

   (a) Applying grease

   (b) Applying paint(

   (c) Applying a coating of zinc

   (d) All of the above.

12.7 LET US SUM UP

- Elements can be classified as metals and non-metals.
- Metals are lustrous, malleable, ductile and are good conductors of heat and electricity. They are solids at room temperature, except mercury which is a liquid.
- Metals combine with oxygen to form basic oxides. Aluminium oxide and zinc oxide show the properties of both basic as well as acidic oxides. These oxides are known as amphoteric oxides.
- Different metals have different reactivities with water and dilute acids.
- A list of common metals arranged in order of their decreasing reactivity is known as an activity series.
- Metals above hydrogen in the Activity series can displace hydrogen from dilute acids.
- A more reactive metal displaces a less reactive metal from its salt solution.
- Non-metals have properties opposite to that of metals. They are neither

malleable nor ductile. They are bad conductors of heat and electricity, except for graphite, which conducts electricity.

- The surface of some metals, such as iron, is corroded when they are exposed to moist air for a long period of time. This phenomenon is known as corrosion.

2.8 LESSON END EXERCISE

1. Between two metals tin and zinc which metal will be preferred for coating food cans?
2. How can you distinguish between samples of metals and non-metals?
3. What are amphoteric oxides? Give one example of amphoteric oxide.
4. What is corrosion? How can it be prevented?

12.9 SUGGESTED FURTHER READINGS

Corrosion Prevention Methods. https://eoncoat.com/corrosion-prevention-methods/

Metals and Non-metals (2020). Chapter 3 from NCERT Class 10th Science Book.

Metals and Non-metals (2020). YouTube link https://youtu.be/AJbe5THaNuU

Metals versus Non-metals. https://www.thoughtco.com/metals-versus-nonmetals-608809

12.10 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress-1

1. (a) zinc
2. (a) Sodium is a very reactive metal.
3. (a) electricity

   (b) more

   (c) hydrogen

Check Your Progress-2

1. (b) Acidic

2. (a) F

(b) F

(c) T

(d) F

Check Your Progress-3

1. (a) moist air

2. (d) Iron (Fe)

3. (d) All of the above