FEDERAL DEMOCRATIC
REPUBLIC OF ETHIOPIA
MINISTRY OF EDUCATION

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Teacher's Guide – Grade

# Physics

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## Grade 12

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# Physics

## *Teacher's Guide*
## *Grade 12*


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## Foreward

Education and development are closely related endeavors. This is the main reason why it is said that education is the key instrument in Ethiopia's development and social transformation. The fast and globalized world we now live in requires new knowledge, skill and attitude on the part of each individual. It is with this objective in view that the curriculum, which is not only the Blueprint but also a reflection of a country's education system, must be responsive to changing conditions.

It has been almost three decades since Ethiopia launched and implemented new Education and Training Policy. Since the 1994 Education and Training Policy our country has recorded remarkable progress in terms of access, equity and relevance. Vigorous efforts also have been made, and continue to be made, to improve the quality of education.

To continue this progress, the Ministry of Education has developed a new General Education Curriculum Framework in 2021. The Framework covers all pre-primary, primary, Middle level and secondary level grades and subjects. It aims to reinforce the basic tenets and principles outlined in the Education and Training Policy, and provides guidance on the preparation of all subsequent curriculum materials – including this Teacher Guide and the Student Textbook that come with it - to be based on active-learning methods and a competency-based approach.

In the development of this new curriculum, recommendations of the education Road Map studies conducted in 2018 are used as milestones. The new curriculum materials balance the content with students' age, incorporate indigenous knowledge where necessary, use technology for learning and teaching, integrate vocational contents, incorporate the moral education as a subject and incorporate career and technical education as a subject in order to accommodate the diverse needs of learners.

Publication of a new framework, textbooks and teacher guides are by no means the sole solution to improving the quality of education in any country. Continued improvement calls for the efforts of all stakeholders. The teacher's role must become more flexible ranging from lecturer to motivator, guider and facilitator. To assist this, teachers have been given, and will continue to receive, training on the strategies suggested in the Framework and in this teacher guide. Teachers are urged to read this Guide carefully and to support their students by putting into action the strategies and activities suggested in it.

For systemic reform and continuous improvement in the quality of curriculum materials, the Ministry of Education welcomes comments and suggestions which will enable us to undertake further review and refinement.

ADDIS ABABA, ETHIOPIA
August 2023

FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA
MINISTRY OF EDUCATION

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## Preamble

Science education is instrumental in the development of any nation. Throughout history, success in science and technology has helped countries develop. Physics can be regarded as the most fundamental of the natural sciences, and instrumental in scientific innovations and technological advancements. Physics generates fundamental knowledge needed for the development of other sciences, health education, economic development, advancements in communication, energy and transportation, and protection of the environment. Physics has made significant contributions to advances in new technologies by helping us understand scientific phenomena and creating theories critical to the development of new products that have dramatically transformed modern-day society. Physics like any other science subject must always be taught practically, either in in the classroom, in the laboratory or outside, in the real world. The new physics student textbook and Teacher‘s Guide follow the competency-based approach to learning. It is a system which challenges the traditional practice of focusing on coverage of the content without paying due attention to mastery of skills. It is a systems of instruction, assessment, grading and academic reporting that is based on students demonstrating that they have learned the knowledge and skills they are expected to acquire as they progress through their education.

For the learner to be competent later in life means that you, as the teacher should be effective. You must provide him/her with resources (knowledge, know how and know being) and teach your learners how to use these resources to solve a problem.

**Knowledge**

i) Knowledge of terminology and specific facts

ii) Knowledge of conventions and units used in physics

iii) Familiarity with experiments suggested in the curriculum.

iv) Knowledge of common laws/principles and generalization identified in the curriculum.

**Know how**

i) Application of knowledge/theory to practical situations

ii) Devise experiments to test hypotheses and statements of models

**Know being (the values, attitudes, behaviors)**

i) Knowledge of the learning competencies for each unit (identified at the beginning of each chapter)

ii) Knowledge of the learning competencies for each topic in a unit (identified at the beginning of each first-level section)

iii) Understanding of the requirements of the activities and experiments

iv) Application of knowledge and practise of competencies in situations relevant to everyday lives

v) Assessment of all competencies at the end of each unit.

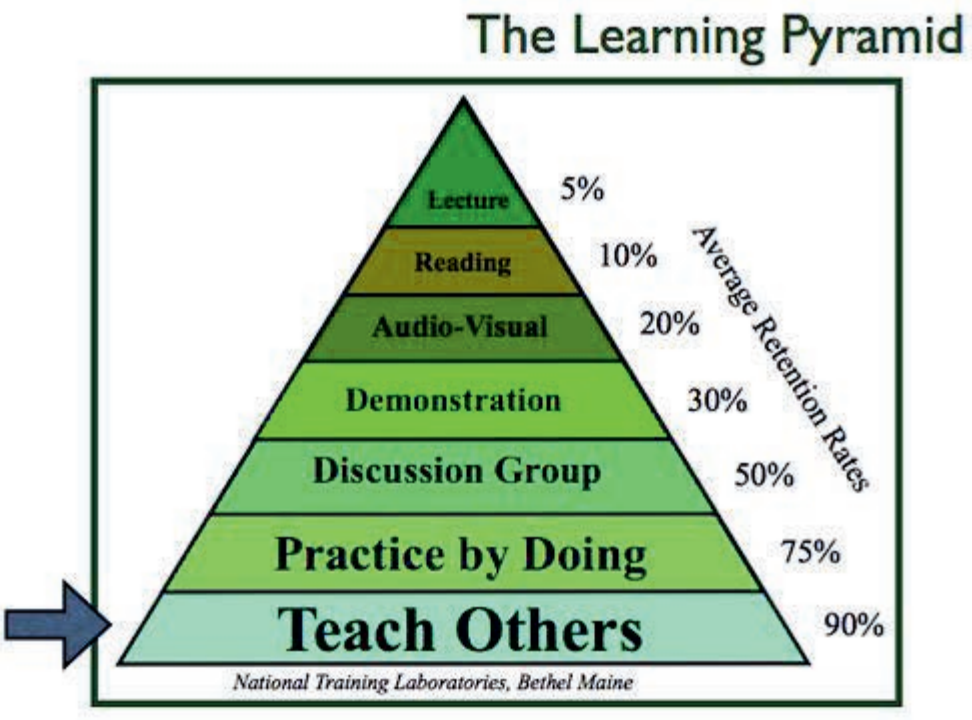
Teacher effectiveness is related to student learning outcomes, including student motivation and achievement. Teachers‘ beliefs, perceptions, actions, attitudes, and interests toward science teaching, teaching techniques, and teaching behaviors in classroom practice are teachers‘ characteristics that affect students‘ motivation and learning. When students have a lack of motivation there can also be a lack of intention and satisfaction; this results in a decrease in their achievement. Effective teaching represents a process of transferring knowledge to support students‘ knowledge construction by promoting their learning and motivation. The effectiveness of a teacher is measured in terms of:

- teacher preparation.
- career plans, pedagogical knowledge.
- subject matter knowledge.
- interactional behavior between teachers and students.
- classroom management behavior and attitudes towards the discipline.
- answering students‘ questions related to physics.

- The following activities and personalities can assist you in being an effective teacher:
- Be clear about instructional goals
- Be knowledgeable about curriculum content and the strategies/pedagogy for teaching it.

- Learn something new every day to improve subject matter and pedagogy
- Make expert use of existing instructional materials in order to devote more time to practices that enrich and clarify the content
- Be knowledgeable about your students, adapt instructions for their needs and understand in advance misconceptions in their existing knowledge.
- Like your students
- Listen to Students
- Motivate students with a smile and kind words
- Patiently handle challenging situations (related to students, family, policy,…)
- Collaborate with other teachers
- Develop relationships with parents
- Maintain classroom organization
- Accept responsibility for student outcomes.
- Apply effective citizenship in the school;

The diagram below is a learning pyramid, showing the active and passive stages of learning. Try to remember this when you are planning and carrying out your teaching.



The current trend of physics teaching in secondary schools is in such a way that the concepts of physics are mostly taught via rote memorization where the teachers transfer physics knowledge to the students, filling their minds with facts, concepts, principles and laws. However, the effectiveness of teaching physics depends on the practical activities that teachers and students undertake in the process of learning the subject. Practical work is engaging the learner in observing or manipulating real or virtual objects and materials. The lack of practical work is a direct factor the poor quality of education, especially in physics. The theoretical teaching of physics without practical work takes students beyond their sphere of experience and understanding the subject is very difficult. Therefore, they lack interest in the subject. Dear physics teacher please be aware how much you are helping your students understanding when your teaching is supported by practical activities involving the students. Understand also students are responsible on their own learning supported by your proper guidance. Understanding physics can be improved by employing active/cooperative/collaborative approaches, where learners are involved in varied activities led by a teacher. As the diagram of the learning pyramid shows, the more students are involved in their own learning improves their understanding.

**Considerations in selecting teaching methods and strategies**

The teaching methodology is crucial for the successful implementation of the curriculum. Teachers must therefore, carefully select strategies appropriate for the learning situation and the needs of learners. Achieving the aims and objectives set in the new curriculum necessitates the employment of participatory teaching and learning approaches in which learners are at the center of the process. Teachers are expected to be facilitators of learning, rather than fountains of knowledge, and students‘ partners in the process that helps them to continue learning to learn.When employing teaching strategies, teachers have the opportunity to choose from a multitude of teaching techniques or learning activities including:

- lecture
- small group discussions,
- group or individual projects,
- brainstorming,

- oral presentations,
- problem solving activities,
- debates,
- independent learning,
- drill and practice,
- discovery,
- cooperative learning,
- enquiry based learning,
- differentiation learning etc.

The types of learning activities teachers develop for their subject should depend on several factors including learning outcomes, the situation under which learning takes place, nature and characteristics of learners and the contents and experiences to be learned. The learning activities developed must support students in their effort to achieve learning outcomes. In that connection, the kind of strategies to be employed at the different levels of education should be based upon learner ability, interest, capacity, degree of exposure to educational life, power of imagination and chronological age among others.

Dear teacher, you have the following roles to play while you are delivering the contents in the Grade 12 physics textbook.

1. Identifying learners‘ abilities and using the data to plan the methodology and teaching techniques suitable for teaching and learning
2. Setting outcomes of learning in terms of competencies (knowledge, skills and attitudes) to be achieved
3. Identifying learning activities which would help achieve the intended competencies by taking account of individual differences
4. Creating a friendly learning environment and providing the care and support necessary for learners to learn through critical thinking, creativity, inquiry, investigation, experimentation, problem-solving, innovation, communication, and collaboration.
5. Employing technologies appropriate to learning activities identified and selected

6. Aligning indigenous knowledge and skills with the appropriate teaching-learning activities

7. Assessing learners‘ progress through observation, recording performance, and administering diverse tools of monitoring and evaluation

8. Providing timely feedback for students on their classroom activities

9. Providing feedback on progress students make towards the achievement of objectives for students, parents/guardians and the school.

10. Utilizing outcomes of continuous and periodic instructional assessment for your own and learner development

11. Contextualizing contents to local realties.

The most efficient and long-lasting learning occurs when teachers encourage the development of higher-order thinking and critical analysis skills, which include applying, analyzing, evaluation and creating. Attention should also be paid to developing students‘ affective and psychomotor skills. To make sure that this takes place, you should encourage deep or rich-rather than shallow-coverage of knowledge and understandings. Differentiating work for students of varying abilities.

As you will, of course, understand, each student has different abilities. There can also be a significant difference in age between the oldest and youngest pupil in the class. Some students will learn more effectively by reading a book, some by carrying out a practical activity and some by listening to and absorbing spoken instructions. Some will understand the work very easily, some will take more time. Some will work very quickly through any task you set, some will work slowly. It is impossible for you as a teacher to take all the differences into account all the time, but there are things that you can do to support individuals within a class.

If you have a class of 30 or more pupils this might sound like a daunting task! There are two important things that you need to do to be able to effectively cater for everyone in your class:

1. Know your students. You need to give them opportunities to work in groups and listen to the conversations; you need to mark their written work; you need to ask questions of individuals in class and you need to encourage them to ask you questions if they don‘t understand or just want to

know more. When you know who understands easily, who finds science difficult, who likes to talk, who likes to write, who likes to draw and who likes doing experiments, you will be in a much better position to help individuals.

2. Know your subject. It is unrealistic to expect everyone to remember and understand everything that you do. Students who find science difficult will be overwhelmed if you try and tell them everything. You need to break each topic down into simple steps and make sure that everyone understands the most important ideas.

You can cater for the range of abilities within your group in two main ways:

**Differentiating by outcome**

This can involve providing a set of questions that get progressively more difficult. Everyone gets as far as they can. Alternatively, you can set open-ended tasks in which students demonstrate what they can do. This also gives you the opportunity to give them a choice about how they present their work, which can be very motivating. You may find that the degree of support that you need to provide to individuals, pairs or small groups within the class varies significantly.

**Differentiation by task**

This involves setting different students, or groups of students different tasks. For example, in a practical session some pupils could have instructions provided for them in written form and some could have them in diagram form and some could have a combination of both.

You could provide a set of questions that cover the basic ideas that you judge that everyone needs to understand and a set that are more challenging. The students who you expect to get a grade A could be given the more challenging ones.

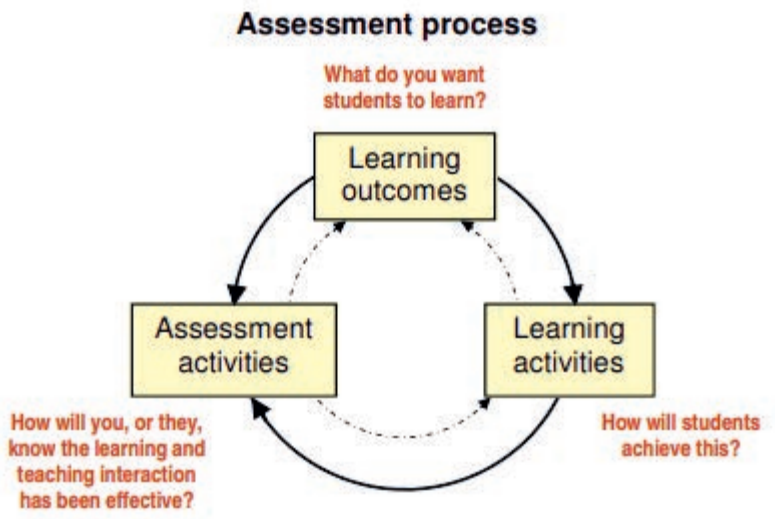
**Learning style**

There is a lot of research that suggests that different students prefer to learn in different ways. The three learning styles that are more commonly referred to are visual, audio and kinaesthetic, i.e. some students prefer diagrams and pictures, some learn best by listening and some prefer to be able to do things. As a teacher you cannot be expected to cater for all

the students all the time, but a good teacher will make sure that their lessons contain activities that cover all three learning styles.

**Assessing Physics units**

In Physics the learning outcomes are assessed using the range of assessment methods specified in the syllabus (in the table of components, weightings and tasks). In deciding what to assess, the starting point is _what do you want students to do and/or learn?‘ and following from this _how will the students engage with the material?‘ which in turn leads to the design and development of learning tasks and activities. It is crucial that at this point the assessment tasks clearly link back to the learning outcomes and are appropriate for the learning activities. The assessment can be used for formative and summative purposes. Assessment can be represented as follows:




Assessment is a continuous process. You should:

- always ask questions that are relevant to the outcomes and content
- use frequent formative tests or quizzes
- check understanding of the previous lesson at the beginning of the next lesson, through questions or a short quiz

- constantly mark or check the students‘ written exercises, class tests, homework activities and so on
- use appropriate assessment methods to assess the tasks.
- Feedback
- When you assess the task, remember that feedback will help the student understand why he or she received the result and how to do better next time. Feedback should be:
    - constructive, so students feel encouraged and motivated to improve
    - timely, so students can use it for subsequent learning

# UNIT 1: Application of physics in other fields

This unit should be completed approximately in 11 periods of teaching time.

**Chapter overview**

Usually, the integration and contribution of physics with other sciences is not obviously known by students. The aim of this unit is to trigger students‘ interest in understanding how different scientific fields are interrelated with each other. The relationship of physics with biology, chemistry, geology and astronomy are discussed. Teachers should inform students that the stated relationships are not the only ones that physics has with the listed subjects. Due to development of science, more relationships are emerging. Try to motivate students explore more relations among the listed scientific fields and other newly emerging fields.

**Introduction**

Dear teacher, begin the lesson by asking questions how knowledge of physics is related with other sciences and then initiate discussion on the application of Physics in other sciences. You can also ask students what can they understand from the chapter starting figure showing the relation of science and technology. Then state the general objective for the chapter.

## 1.1 Physics and other sciences

This section should be completed approximately in 5 periods of teaching time.

**Brainstorming question 1.1: Answer**

Students might list fields like astrophysics, geophysics medical physics, physical chemistry, chemical physics, environmental physics, biophysics and others.

In addition, ask students to think about similar or the same topics learnt from different subjects in their lower grades. Give them one minute to rehearse and make them to reflect. You can list some to initiate them like atomic models from physics and chemistry, energy from chemistry, biology and physics.

After you feedback students‘ reflection, state the general objective of this section for them as it is stated in the students‘ text book.

**Physics and chemistry**

State the specific objective of this section as:

- At the end of this subsection you will be explain how physics and chemistry are related.

**Presentation**

Dear teacher,

Let the learners discuss on Brainstorming question 1.2 in students‘ text book

- Put learners in groups (select appropriate number of learners depending on the size of the class) make sure that they work in harmony. Help them in selecting their group leaders.
- Recognize learners with special needs in group making. Encourage them to actively participate in their respective groups.

Initiate them to discuss in group on the following:

- to list similarities and difference in physics and chemistry subjects from their previous knowledge.
- the importance of thermodynamics (thermal physics) in chemistry (why heat some reaction beaker, why solid melt when heating and solidify when cooled, …)
- the importance of atomic physics for chemists (for example ask them how atoms form chemical bonds? And why atoms form chemical bond).

❖ Move around the class guiding learners while they are discussing. In case of any assistance, you can make brilliant learners to assist the weak ones.

❖ Let the learners discuss their findings in their groups and finally present to the whole class.

❖ Give them appropriate feedback on their presentation and summarize the discussion by raising the major concepts given in the student text under this subsection and the answers to brainstorming question 1.2 as follow.

**Brainstorming question 1.2.: Answer** Both chemistry and physics study matter. They have no clear border in specializations such as physical chemistry, chemical physics, nuclear physics/chemistry, materials science, spectroscopy, atomic physics and others.

(i) In separation of dissolved salt from water by evaporation method, chemists use thermodynamics (thermal physics). Chemists also use thermodynamics concepts in many other activities like reaction mechanism to calculate the energy involved the reaction and to determine the reaction route and the final product.

**Discussion Question 1.1: Answer**

Chemists use advanced instrument like ultraviolet spectrometer, Infrared spectrometer, nuclear resonance magnetic spectrometer, X-ray diffraction, scanning electron microscope, energy dispersive X-ray and other instruments to study composition, structure, properties, behavior and the changes they undergo during a reaction with other substances of minute entities like elements, atoms, molecules and ions. The working principles of these instruments are based on one or more concepts of physics.

**Summary**

Summarize this section by raising the following concepts:

- Both physics and chemistry deals about matter and energy. However, physics looks at this question on a much smaller scale.
- Physics concerns the movement of physical objects in time, while chemistry concerns the transformation of physical matter from one type to another.
- Chemists and physics share such knowledge of physics as:
  - Thermodynamics
  - atomic physics
  - nuclear physics
  - matter and energy
  - Chemical bonding
- The boundary between physics and chemistry is not clear.

**Assessment**

Evaluate students asking them to list some similarities and differences between physics and chemistry.

## Physics and biology

### Introduction

Understanding the relation of physics with biology, especially human, is very important to develop positive attitude in the students‘ mind about the physics subject and a good starting point to show how different scientific fields are inter related. Dear teacher, ask the students Brainstorming question 1.3 to list as many physics concepts from a single cell to the whole-body structure. This is more general question which can arose students‘ motivation to learn the contents included in this subsection. More specific questions are to be dealt under the specific subsections. Understanding this subsection is very important to combine knowledge of physics and biology in medical physics.

State the specific objectives of this subsection as:

- Apply Newton's law to the motion and equilibrium of living system
- Explain how physics of fluid flow is used to understand blood flow in the living organism
- Discuss sound production in human being in terms of physics concepts
- Relate the physics of electricity to the communication of living cells and systems

**Brainstorming question 1.3: Answer**

The laws of physics are important to explain:

- the mechanics of muscles and body movements,
- flow of body fluid, blood and air,
- hearing and audio properties of the ears,
- vision optics,
- heat and energy,
- message transmission.

**Presentation**

**Physics of Newtonian mechanics and biology**

Introduce this section by asking how newton‘s law of motion is related with our body structure and movement. After appropriate feedbacks on the students‘ response, summarize the question by briefing them concepts discussed in this specific subsection.

**Discussion Question 1.2 (i): Answer**

The reason why it is difficult to stand on one foot than two feet is that the wider the base on which the body rests, the more stable it is; that is, the more difficult it is to fall a body with a wider base. In other word the rotational effect of a force, called torque, decreases with increasing base area.

A sleep person is more stable than standing person due to two reasons: (1) a sleeping person has more base area than standing person (2) the center of mass of the sleeping person is closer to the base. A body is more stable if its center of gravity is closer to its base.

Dear teacher, try to show this figure to your students while you feedback this this discussion question.

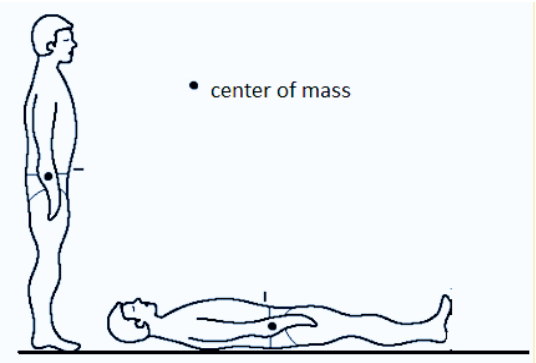



Figure 1.1: The position of center of mass of a standing and sleeping person.

**Discussion Question 1.2 (ii): Answer**

When carrying an uneven load, the body tends to compensate by bending and extending the limbs so as to shift the center of gravity back over the feet. Teacher should also aware students the tendency of the body to compensate for uneven weight distribution often

causes problems for people who have lost an arm, as the continuous compensatory bending of the torso can result in a permanent distortion of the spine.

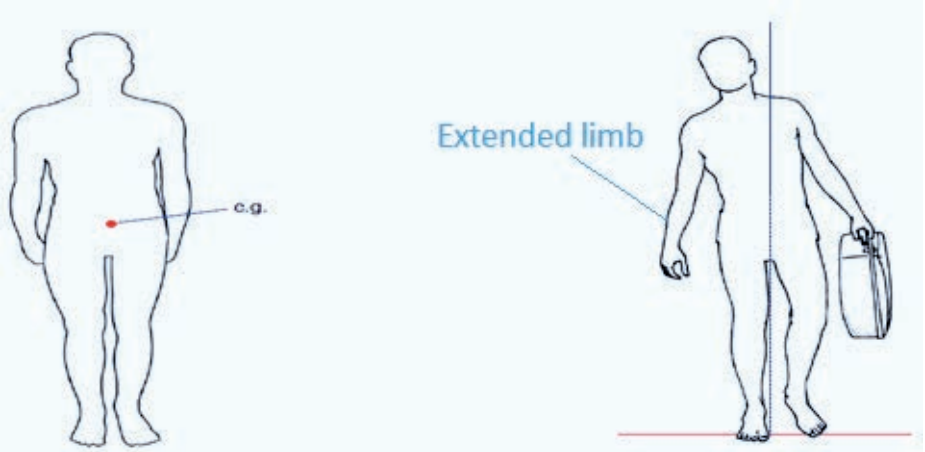



Figure 1.1 (a) shows the center of gravity of freely standing person and Figure 1.1 (b) shows the way how a person carrying a load stands.

**Physics of fluid flow and biology**

The understanding of physics of fluid flow in biology is very important to understand how blood flows in multicellular organism, how soft skeletal organism like worm moves and how water, minerals and food is circulated in plants.

Ask student the Discussion question 1.3, tell them to write their own answer within two minutes. Then, answer the Discussion Question (as stated below) to them and let them compare their answer.

**Discussion Question 1.3 (i): Answer**

Soft-bodied animals such as the earthworm that lack limbs utilize Pascal‘s principle to produce body motion. The structure by means of which this is done is called the hydrostatic skeleton. For the purpose of understanding the movements of an animal such as a worm, we can think of the animal as consisting of a closed elastic cylinder filled with a liquid; the cylinder is its hydrostatic skeleton. The worm produces its movements with the longitudinal and circular muscles running along the walls of the cylinder. Because the volume of the liquid in the cylinder is constant, contraction of the circular muscles makes the worm thinner and longer. Contraction of the

longitudinal muscles causes the animal to become shorter and fatter. If the longitudinal muscles contract only on one side, the animal bends toward the contracting side. By anchoring alternate ends of its body to a surface and by producing sequential longitudinal and circular contractions, the animal moves itself forward or backward. Longitudinal contraction on one side changes the direction of motion.

**Discussion Question 1.3 (ii): Answer**

The circulation of blood through the body is often compared to a drains system with the heart as the pump and the veins, arteries, and capillaries as the pipes through which the blood flows. The blood is pumped through the circulatory system by the heart, and it leaves the heart through vessels called arteries and returns to it through veins (see Figure 1.2).

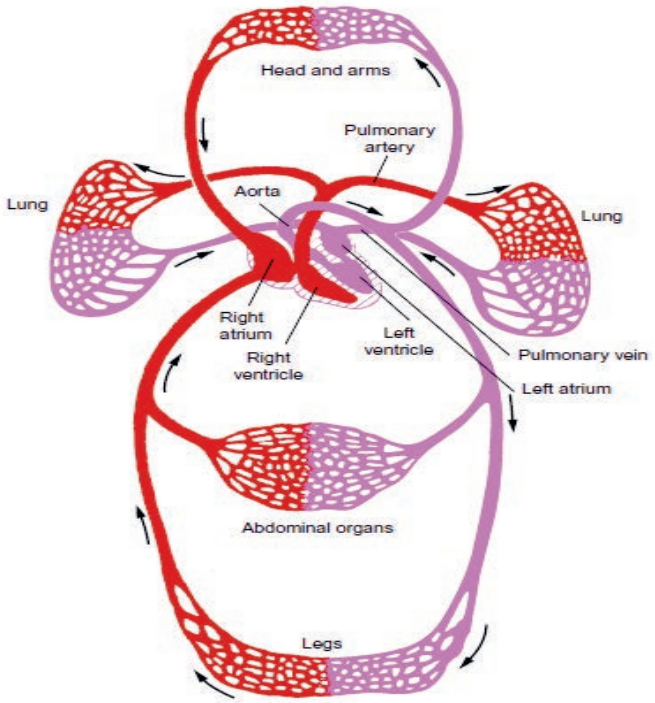



Figure 1.2 Schematic diagram showing various routes of the blood circulation.

Blood from all parts of the body except the lungs enters the right atrium, which contracts and forces the blood into the right ventricle. The ventricle then contracts and drives the blood through the pulmonary artery into the lungs. The blood then flows into the left atrium via the pulmonary vein. The contraction of the left atrium forces the blood into the left ventricle, which on contraction drives the oxygen-rich blood through the aorta into the arteries that lead to all parts of

the body except the lungs. Thus, the right side of the heart pumps the blood through the lungs, and the left side pumps it through the rest of the body. The arterial blood pressure, which is on the average 100 torr, can support a column of blood 129 cm high, so that blood can be easily reach the brain against gravity which is in average 50 cm above the heart.

Because of the pumping action of the heart, blood enters the arteries at a maximum pressure of 120 torr. As the blood flows through the circulatory system, its initial energy, provided by the pumping action of the heart is dissipated by the expansion and contraction of the arterial walls and viscous friction associated with the blood flow. The blood pressure, therefore, decreases continuously. The pressure drops still lower in the veins and is close to zero just before returning to the heart. In this final stage of the flow, the movement of blood through the veins is supported by the contraction of muscles that squeeze the blood toward the heart from all parts of the body including the feet.

**Physics of sound wave and biology**

Tell students to read this subsection in pair in two minutes and let 3 -5 pairs to reflect what they understood. Summarize the main concept under this subsection while feed backing the students‘ reflections. Then tell students to practice Activity 1.1 below.

**Activity 1.1: Answer**

Dear teacher, make students try to create sound while they are exhaling and inhaling air. Make sure that their sound is not disturbing neighboring classrooms. Then ask them which way enable to create a controlled speech sound. The answer is, a controlled sound is created by exhaling air than inhaling air. The reason is that:

- Energy comes from the air supplied by the lungs.
- The vocal folds produce sound at the larynx.
- The sound is then filtered, or shaped, by the articulators (the tongue, the upper lip, the lower lip, the upper teeth, the upper gum ridge (alveolar ridge), and more).

The ability to control exhalation allows long phrases to be sung in a controlled and relaxed manner.

**Summary**

Summarize your class by reminding students the following points:

- **Newtonian mechanics tells a biologist about:**
  - How different animals and their body parts move.
  - muscle movements and physical behavior of bones, lungs and the heart
  - equilibrium of the body
- **Physics of fluid flow tells a biologist about:**
  - The circulation of blood in multicellular organism
  - Movement of soft-body animals like worms
- **Physics of sound wave tells a biologist about:**
  - Mechanism of sound creation and transmission

**Assessment**

Ask students the following questions:

- What is the importance of understanding Newtonian mechanics, fluid flow and physics of sound for a biologist?

**Home work**

Tell students to read the next subsections –Physics of electricity and biology" and –Optical Physics and biology" and write the major concepts under the subsections.

**Physics of electricity and biology / Optical Physics and biology**

**Introduction**

The subsection –Physics of electricity and biology" is very important to understand how our body functions are coordinated by using electric signals. Optical physics also play significant role in biology to study light related properties and optical instruments like microscopes.

In relation to physics of electricity and biology, ask students to discuss how our different systems are organized to do different functions which are vital for the existence of the whole body. Ask them also how can we interpret what have seen, touch, tasted, smelled, and heard? Make students to reflect individually for four minutes and feedback them appropriately.

In relation to optical physics and biology ask students, what is the importance of light in biology? Make students to reflect individually for two minutes and feedback them appropriately.

State the specific objectives of this lesson for the students as follow:

At the end of this class you will be able explain:

- The importance of physics of electricity in biology
- Contribution of optical physics for biology

**Presentation**

Tell students to make groups consisting of 3-5 students per group. Fix number of students and number of group that is appropriate to your class room situation. Then, tell them to share what they have understand from their reading homework you have given them to read the ―Physics of electricity and biology" subsection in your previous class. Give them 5- 7 minute to share their understanding. Then ask them the following questions to answer in group.

- How can we interpret what have seen, touch, tasted, smelled, and heard?
- How our brain receives and sends message from different parts of the body?
- What are the message transmission means in our body?
- In what form the message is transmitted?
- Compare this message transmission with message transmission in modern communication technologies?

Give feedback students reflection properly based on the concepts presented in the text.

Now, ask students to respond individually about what they have understood from reading home work about relation of ―optical physics and biology" in order to answer the questions:

- What is the importance of light for plants and animals?
- What is the benefit of a biology from optical physics?

Give appropriate feedback for the students' response based on the concepts stated under the subsection ―optical physics and biology".

**Summary**

Summarize your lesson as follow:

- The nervous system of animals and the control of muscle movement is controlled by electrical interactions.
- Neurons are message transmitting networks in our body with the brain as the center of the network

- The message in our body is transmitted as electric pulse by the neurons
- Our electrical condition measured externally can give our health condition
- shark uses electric signal to locate their prey and to communicate with other sharks.
- electric eel can generate along its skin electric pulses up to 500 V
- Though electric signal is always there in our body, a current larger than about 10 mA damages our body by contracting muscles
- Light is important for animals to see objects and for photosynthesis for plants
- Optical physics supports biology by providing optical instruments, like microscopes, which are important to study biological properties.

**Assessment**

Ask students:

- What is the importance of physics of electricity in biology?
- What is the importance of optical physics in biology?

Ask students discussion Question 1.4 question and Give feedback as follow:

**Discussion Question 1.4: Answer**

The act of ‗seeing' an object is the result of light from any luminous source. When a beam of light falls on an object from the source of light then this light gets reflected in all directions after striking that object. The reflected light then reaches our eyes and our brain interprets the object. Finally, we are able to see objects around.

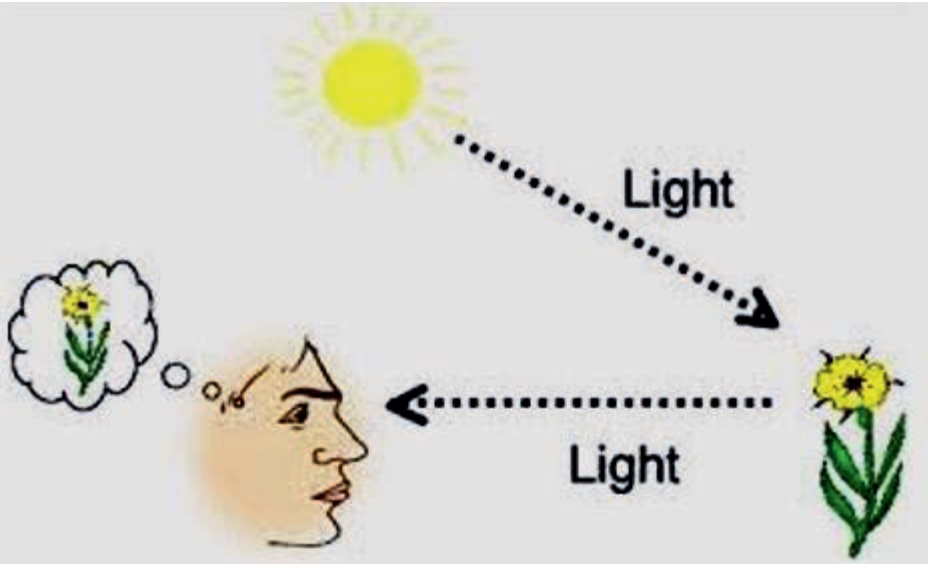



Figure 1.3 How we can see objects

## Physics and astronomy

### Introduction

Ask students what astronomers study about, what relation do physics and astrophysics have? After students reflected individually for two minutes state the objective of this section as:

At the end of this subsection, you will be able to:

- Explain how astronomers use Newtonian mechanics to study astronomical objects.
- Discuss how atomic physics is used to study the nature and composition of astronomical objects.
- Relate the nature of astronomical objects with the type of electromagnetic waves they have emitted or absorbed.
- Differentiate types of telescopes.

### Presentation

Ask students to define astronomy. Let students write their answer individually on the piece of paper and then compare their answer with the nearby colleagues.

To discuss on Brainstorming question 1.4:

Put learners in groups with appropriate number depending on the size of the class. Make sure that they work in harmony.

Let them discuss how can astronomers get information about far astronomical objects and what physics concepts do astronomers use to study astronomical objects. Move around the class guiding learners as they are performing the activities. Feedback them properly in relation to their discussion reflections and the suggestions given in Brainstorming question 1.4 below.

### Brainstorming question 1.4: Answer

Astronomers study objects far from them (Earth). Astronomers try to study astronomical objects by studying the component of electromagnetic radiation from these objects. Until

17th century all astronomical studies were limited to naked eye observations to measure positions of celestial objects in the sky. Starting from 17th century, man used to use different types of telescopes to investigate astronomical objects. A telescope is an optical instrument using lenses, curved mirrors, or a combination of both to observe distant objects, or various devices used to observe distant objects by their emission, absorption, or reflection of electromagnetic radiation. The first known practical telescopes were refracting telescopes invented at the beginning of the 17th century, by using glass lenses. They were used for both terrestrial applications and astronomy. In 1609 Galileo (and few others) used a refracting telescopes to observe the sky and turned a new age of astronomy based on telescopes. Currently, many new types of telescopes are in use. Telescopes may be classified by the wavelengths of light they detect:

- X-ray telescopes, using shorter wavelengths than ultraviolet light
- Ultraviolet telescopes, using shorter wavelengths than visible light
- Optical telescopes, using visible light
- Infrared telescopes, using longer wavelengths than visible light
- Submillimetre telescopes, using microwave wavelengths that are longer than those of infrared light
- Radio telescopes that use even longer wavelengths

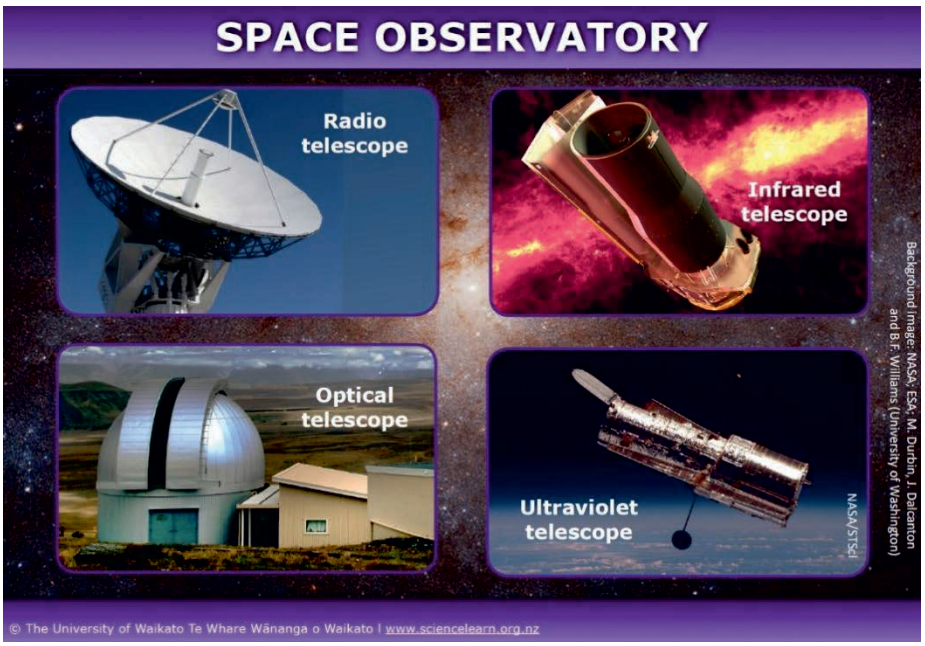


Figure 1.4 Different types of telescopes

Students have to be informed that Ethiopia also has space observatory telescope in Entoto observatory as shown in Figure 1.3 of students‘ text. Ethiopia is the fifth nation in Africa to have such advanced observatory reflective telescope next to South Africa, Nigeria, Egypt and Morocco. The Entoto observatory owns two professional Astronomical Telescopes.

**Newton’s laws of motion and astronomy**

Under this subsection you have to notify students that astronomers used basic physics laws like Newton‘s law of gravitation to investigate the nature and motion of astronomical objects by using Kepler‘s law of motion in addition to direct observations using different telescopes.

**Physics of Electromagnetic wave and astronomy**

In this subsection students have to identify the components (spectrums) of electromagnetic waves and the relation between their energy and wavelength. They also understand why human eye detect small range (called the visible range) of the spectrum only. They have to identify the relation between the colour and the energy of the visible part of the electromagnetic spectrum. Remind them this energy-colour relation can be used to guess the temperature of the astronomical objects by observing their colour.

**Physics of atoms and astronomy**

Dear teacher, make students to reflect on the subatomic particles, electron, proton and neutron and how they are arranged inside the atom. Feedback them to understand how electrons are arranged in a quantized orbit as stated by Bohr‘s model as shown in Figure 1.5 in the student‘s text. These quantized orbits are characteristics of a given atom and can be used for the identification of different substances. Electron can only jump from one orbit to another by absorbing or releasing quantized energy. This forms an absorption or emission line spectra peculiar to that specific atom. Similarly, this concept can be used to identify the composition of astronomical bodies from their emission or absorption line spectrums.

**Brainstorming question 1.5: Answer**

As explained under Brainstorming 1.4 astronomers use telescope to detect the component of electromagnetic spectrum coming from astronomical objects. The light (electromagnetic wave) contains important information about the source of the light. The physics of electromagnetic wave tells as the nature of astronomical objects including the composition, temperature, age, velocity and distance of the astronomical objects.

**Exercise 1.1: Answer**

Astronomers commonly use light year as a unit of distance between astronomical objects including Earth. A light year is the distance the light travel in one year. Therefore, from the relation , where and are distance, velocity and time respectively, we have

where is speed of light,
. Therefore, 1 light year is

**Brainstorming question 1.6: Answer**

The lines on the atomic spectrum relate to electron transitions between energy levels, if the electron drops an energy level a photon is released resulting in an emission line and if the electron absorbs a photon and rises an energy level an absorption line is observed on the spectrum. Since each atom has its own peculiar emission and absorption spectra, one can learn the type of atom and its temperature from their emission and absorption line.

## Summary

Summarize this subsection as follow:

- Astronomers use Newton‘s law of gravitation
    - to describe the motion of astronomical objects around an orbit.
    - Mass of astronomical objects

- Astronomers use light to:
    - Measure distance between astronomical objects.
    - study the properties of astronomical objects from the properties of the light they emit.
    - The energy emitted by the astronomical objects
    - Temperature of the astronomical objects
- Astronomers use different telescope to detect the type of light coming from the astronomical objects
- Astronomers used light year as an astronomical distance measuring unit.
- Atomic physics plays a key role in astrophysics as light from astronomical objects is emitted through atomic transitions.

**Assessment**

Evaluate students understanding by asking the following questions:

i) what concepts of Newtonian mechanics do astronomers use to study astronomical objects?
ii) How atomic physics is used to study the nature and composition of astronomical objects?
iii) List the type of telescopes astronomers use to study astronomical objects.

**Home work**

Tell them also to gaze stars in the night time and notify the difference in visibility and colour of the stars. And also remind them why this visibility and colour differences occur.

## Relation of physics with geology

### Introduction

Dear teacher, start this subsection asking students what they know about geology and geophysics. Make them to guess the similarities and differences between these fields. How could they be related to physics? Give them about three minutes to think and reflect. Feedback them according to their responses and then state the specific objective of this subsection for the students as:

At the end of this subsection, you will be able to:

- Explain the relation of physics with geology.

**Presentation**

Dear teacher, group the whole class in three groups and tell them to answer the following questions. You can make subgroups under each group to facilitate the group work, however, all the subgroups under a given group answer the same question. Group one answer question 1, group 2 answers question 2 and group 3 answer question three. They can get the answers when they read the text line by line sequentially.

1. What Earth Science studies about?
2. What Geology studies about and what is its difference with Earth science?
3. What basic physics concepts are used to explain common geological processes and should geologists always make excavation to study the properties of minerals and rocks?

Make the students to reflect their answer for the questions they are asked. Give them appropriate feedback based on the brief note on the students' text.

**Summary**

Summarize the section raising the following:

- Earth Science deals with all aspects of the Earth including molten lava, icy mountain peaks, steep valleys and towering waterfalls, the atmosphere, planet's core.
- Geology is the study of the solid matter that makes up Earth, like rocks, minerals, mountains, and canyons.
- Common geological processes and the analytical techniques use basic physics concepts like force, optics, atomic structure, electromagnetic radiation, heat and heat flow, electricity and magnetism, stress and strain, sea waves, acoustics and fluids and fluid flow.

**Assessment**

(i) What is the difference between Earth science and geology?

(ii) What physics concepts are used in exploring minerals and study the nature of rocks within the earth?

**Activity 1.2 (Homework)**

Dear teacher, please facilitate the group activity 1.2 by helping students how they make groups; how politely they approach the other science teachers and What questions to ask. Tell them clearly what to do before actual questionnaire, during questionnaire and after completing the questionnaire. They have to be informed that they will present the summary of the questionnaire for the class so that they have to take important note during the oral questionnaire.

## 1.2. Physics and Engineering

This section should be completed approximately in 2 periods of teaching time.

**Introduction**

Dear teacher, ask students the Brainstorming question 1.7. Help them to remember their previous physics knowledge (example equilibrium) applied to easily observable engineering (construction of bridge that support heavy trucks). Make them to try their own examples. Then state the specific objectives of the section as stated in the students' text book.

**Presentation**

Start your presentation answering brainstorming question 1.7 as stated below.

**Brainstorming question 1.7 (i): Answer**

The importance of physics for different engineering fields is to generate fundamental knowledge to be used by the engineers to design some engineering products/technologies as shown in Table 1.1.

Table 1.1 Lists some important technologies and the principles of physics they are based on.

| **principles of physics** | **Technologies** | **principles of physics** | **technologies** |
|---|---|---|---|
| Laws of thermodynamics | Steam engine | Superconductivity | Ultrahigh magnetic field |
| Controlled atomic fission | Nuclear reactor | Faraday's law of induction | Electric generator |
| Generation, transmission and reception of electromagnetic waves | Radio and TV | Conversion of energy | Hydroelectric power |
| Stimulated emission of radiation | Laser | Fluid dynamics | Airplane |
| Digital logic | Computer | Lorentz force | Particle accelerators |
| Newton's laws of motion | Rocket | Total internal | Optical fibers |

| | | | |
|---|---|---|---|
| | propulsion | reflection | |
| Reflection of sound | Radar and sonar | Wave nature of matter | Electron microscope |
| Magnetic confinement of plasma | Fusion reactor | Photoelectric effect | Photocell |
| Reflection and refraction of light | Telescope | Semiconductor physics | Transistor |

**Brainstorming question 1.7 (ii): Answer**

Since engineering is application of physics and other science to solve real world problems and make life easy, the engineers success in applying the principles and theory of physics depends on their understanding of the physics or science they use to design some engineering product. So, we can conclude that yes, the engineer must understand physics at least at an application level. Otherwise, the engineer would possibly not know where to start.

**Civil Engineering**

Summarize this subsection for students as follow:

- Civil engineering deals with the design, construction, and maintenance of the physical and naturally built environment, including public works such as roads, bridges, canals, dams, airports, sewerage systems, pipelines, structural components of buildings, and railways.
- Civil engineering has been known since ancient civilizations in Ethiopia, Egypt and other nations before the development of physics as a disciple.
- However, the major change in civil engineering resulted from the development of physics after the development of laws of motion, power and energy in the eighteenth century.
- In Civil Engineering, the laws of physics can tell you about forces, tension, harmonic vibrations and oscillations, tensile strength, elasticity, and all kinds of other concepts that you can use to make calculations about your designing and construction work.
- Tell students civil Engineering practices in Ethiopia from ancient to modern period showing the figures from the students‘ text.

**Mechanical Engineering**

Summarize this subsection for students as follow:

- Mechanical engineering deals with construction of aircraft, watercraft, engines, robotics, weapons, cars, pneumatics, hydraulics and others by using core areas of physics including mechanics, dynamics, thermodynamics, materials science, structural analysis, and electricity.

**Electrical and electronic engineering**

Summarize this subsection for students as follow:

- Electrical engineering involves designing electrical circuits including motors, electronic appliances, optical fiber networks, computers, and communication links.
- Electrical engineers need understanding of physics concepts like mechanics, thermodynamics, integrated circuits, transistor logic and Electromagnetism.
- Electronics engineering deals with semiconductors, diodes, transistors and, integrated circuit.
- Electrical and electronics engineering are very related. Electrical engineering leads to electronics engineering and finally to computer engineering & information technology and artificial intelligence. Physics can be considered as a mother of all engineering.
- Thus, it is true that Physics has a significant role in most areas of Engineering.

**Chemical engineering**

**Summarize this subsection as follow**

- Chemical engineering involves the production of products through chemical processes.
- chemical engineering requires an understanding of the physical properties of molecules, the chemical bonds between atoms as well as the molecular dynamics which are dealt by molecular physics.
- concept of energy changes are also very important in chemical engineering.

**Technology generating new physics**

Dear teacher, pose a brainstorming question 1.8: Without knowledge of physics, most of the technologies we know well today could not be available for the society. Do you think the revere also is true? i.e., can technology give rise to new physics? Give them few minutes to think and let them reflect. Make them to support their response by examples.

**Summarize this subsection as follow:**

Technology contributes to physics in the following way:

- Technology has played an enormous role to reach atomic scales as well as huge and distant astronomical objects to create physics there.
- Technology produced instruments, like particle accelerator, electron microscopes, different types of X-ray machines, highly helped the development of physics in the atomic scales.
- Space technology has opened to do physics in space and astronomical objects
- Computer-based Technology helps us to analyze huge data within short period of time. Analyzing data is the core process in physics. Knowledge of physics can be generated by analyzing data.

**Summary**

Summarize your lesson as follow:

- Engineering is basically physics applied to create something more practical. It can be mechanical, electrical, civil, etc., but they‘re all basically governed by physics laws. Physics has a significant role in most areas of Engineering.
- Without knowledge of physics, most of the technologies we know well today could not be available for the society. Technology has played an enormous role in developing physics. Thus, the link is kind of two-way. However, physics leading to new advances in technology is far more likely than vice versa.

**Assessment**

❖ What physics knowledges are important in

(a) Civil engineering (b) mechanical engineering (c) electrical engineering (d) electronics engineering

❖ List some technologies that contribute for the development of physics

**Homework**

Dear teacher, give questions under Activity 1.3 as a homework.

**Activity 1.3 (i): Guiding points**

Dear teacher, group the students in to four in order to report on the civil, mechanical, electrical and chemical engineering applications and the corresponding physics concepts that are available around their living area. They can use the following table:

Table 1.2 Physics concepts in engineering

| **Civil Engineering** | **Physics concepts** |
|---|---|
| House building | force, tensile strength, torque, |
| Road and drainage | Friction, force, fluid mechanics, thermal expansion, |
| | |
| | |
| | |
| | |
| | |

Similar table can be used for other engineering fields and technologies.

**Activity 1.3 (ii): Guide**

Dear teacher, guide students to get the intended information based on the availability of the sources in the students‘ locality. The same group formed under activity 1.3 (i) can work together, but they have to consider latest technologies like in space, nanotechnology, biomedical, biotechnology, and others that use physics discoveries.

**Activity 1.3 (iii): Guide**

Dear teacher, tell the students about the concept of the poster presentation. And then arrange them in group to prepare a poster on the title –Contribution of different technologies on the advancement of physics".

## 1.3. Medical physics

This section should be completed approximately in 2 periods of teaching time.

**Introduction**

Start this section by asking students the brainstorming question 1.9. Initiate them to list simple (like thermometer, stethoscope, otoscope, …) to complex (like X-ray, ultrasound, …) medical instruments and ask them also to suggest what physics concepts are used in these instruments.

**Brainstorming question 1.9: Answer**

The physics concepts used by the above listed diagnostic equipment and the information from them include:

- Thermometer uses the thermal physics and reads temperature of a body
- Stethoscope use the physics of sound wave and reads the heart beats.
- Otoscope uses physics of optics as it uses magnifying lens and examines examine the condition of the ear canal.
- X-ray uses physics of electromagnetic wave (X-ray) and examines the injuries in the tissues.
- Ultrasound uses the physics of sound wave and examines the nature of the sound reflected by different tissues.
- Many medical instruments also use electronic physics for displaying the results and controlling the instruments.

State the specific objectives of this section as stated in the students' text.

**Presentation**

Tell students:

- how the discovery of Wilhelm Contra Roentgen revolutionized the medical physics field

- the significance of medical physics in current diagnostic and therapeutic medication by mentioning some of the diagnosing and therapeutic instruments and their functions.
- Emphasize how different concepts of physics are important in the advanced diagnostic and therapeutic medical instruments. For example, X-ray diagnosis is based on how X-ray is transmitted or blocked when it passes through body tissues, MIR diagnosis is based on the arrangement of nuclear magnetic spins of elements or compounds present in the body, ultrasound diagnosis is based on the reflection or echo of sound waves.

**Magnetic Resonance Imaging (MRI)**

Use lecture method supported by question and answering to teach this advanced concept.

Start this subsection by asking students to share their experience (if any) about the MRI diagnostic equipment, like the appearance of the equipment, what pre-diagnosis advice is given by the MRI specialist, how diagnosis is carried out, any patient‘s feeling during diagnosis, what is the diagnosis result looks like.

Student has to aware that what is measured in the MRI is the nuclear magnetic spin of hydrogen in the water molecule which is the common element in the body. Give students a short note from the text and the answer from discussion question 1.5 below.

**Summary**

Summarize this section as follow:

- Hydrogen proton in our body acts as a tiny magnet oriented randomly.
- It aligns, without physical movement, to the scanner‘s stronger magnetic field $B_o$, .
- Second magnetic field that varies along the body (gradient field) in 3D direction is applied to locate the appropriate area of imaging.
- Radio frequency pulse that matches to the particular precessing frequency of the hydrogen protons is applied on the intended body.
- The hydrogen proton that oscillate by the frequency of this RF pulse absorbs energy and be flipped away from the $B_0$ field.

- When the RF pulse is turned off, the protons flip back and realign along the main magnetic field, $B_0$ giving off energy.
- Different tissues in the body give off different amounts of energy.
- Because protons in the different kinds of tissues in the brain, such as gray matter, white matter and blood, all give off different amounts of energy, the result of the transformed energy gives a highly detailed image of the tissue inside the brain.

**Assessment**

Use discussion question 1.5 as assessment question.

**Discussion question 1.5: Answer**

MRI is based on technology that excites and detects the change in the direction of the rotational axis of protons found in the water that makes up living tissues. Image formation is to define the spatial location of the sources that contribute to the detected signal (hydrogen spin moment). MRIs employ powerful magnets which produce a strong magnetic field that forces protons in the body to align with that field. The spatial information of the proton pools (nuclear magnetic moments) contributing MR signal is determined by the spatial frequency and phase of their magnetization. When a radiofrequency current is then pulsed through the patient, the protons are stimulated, and spin out of equilibrium, straining against the pull of the magnetic field. When the radiofrequency field is turned off, the MRI sensors are able to detect the energy released as the protons realign with the magnetic field. Gradient coils generate spatially varying magnetic field so that spins at different location precess at frequencies unique to their location, allowing us to reconstruct 2D or 3D images. The time it takes for the protons to realign with the magnetic field, as well as the amount of energy released, changes depending on the environment and the chemical nature of the molecules. Physicians are able to tell the difference between various types of tissues based on these magnetic properties.

**Home work**

Order students to read the following subsections

- X-Ray computerized tomography (CT) scan

- Clinical Uses of Sound: Stethoscope and Ultrasound
- Radiation Therapy

**Introduction**

Start this section by asking students to share their experience about the X-ray and CT scan diagnostic equipment, like the appearance of the equipment, what pre-diagnosis advice is given by the X-ray or CT scan specialist, how diagnosis is carried out, any patient‘s feeling during diagnosis, what is the diagnosis result looks like.

**Presentation**

Group the class in to three to share what they have read in their homework on subsections X-Ray computerized tomography (CT) scan, Clinical Uses of Sound: Stethoscope and Ultrasound and Radiation Therapy.

Group one share what they have understood about X-Ray computerized tomography (CT) scan, Group two share what they have understood about Clinical Uses of Sound: Stethoscope and Ultrasound and Group three share what they have understood about Radiation Therapy

You can make subgroups under the groups which are manageable in your class room situation. Give them 5 minutes to share each other what they have understood from their reading homework on the topics as stated above.

**X-Ray computerized tomography (CT) scan**

**Brainstorming question 1.10: Answer:** Make them to share their experience to the whole class.

Let the subgroup one representative(s) present what they understand about ―X-Ray computerized tomography (CT) scan”. Feedback appropriately based on their reflection.

Be sure whether students understand the following:

- both X-ray and CT scan use X-rays for diagnostic purpose.
- The image formation in both cases depend on the blockage and transmission of X-rays by the tissues of the body.
- how density of elements in the body affects X-rays blockage.

**Discussion Question 1.6: Answer**

Basic difference between the conventional X-ray and CT scan includes X-ray has a fixed detector while CT scan has rotating detector, X-ray images are two dimensional that of CT scans are 3 dimensional. Tell students to summarize as follow

Table 1.3: Summary of X-ray and CT scan

| **X-ray** | CT Scan |
|---|---|
| Creates 2D images | Creates 3D images |
| Used primarily to see bones and to detect cancer and pneumonia | Used primarily to diagnose conditions in organs and soft tissues |
| Most common and widely available | More powerful than X-ray |
| Use radiation to produce image | Take 360-degree image |
| Has fixed detector | Has rotating detector |

**Clinical Uses of Sound: Ultrasound**

Start this section by asking Brainstorming question 1.11 for the whole class.

Give feedback for this brainstorming question as follow:

**Brainstorming question 1.11: Answer**

Lung and heart are the two audible sound creating organs under a person‘s chest. Heart and lung sounds are the result of mechanical interactions that indicate operation of cardiac and respiratory systems, respectively. Doctors mostly use a stethoscope to hear these sounds. They interpret these sounds whether our organs like heart, lung, major blood vessels and the whole abdomen function properly or not.

Let group two students share what they have understand from their homework reading and class discussion on ―Clinical Uses of Sound: Stethoscope and Ultrasound. Feedback them appropriately.

Make sure students understand the following:

- Difference between sound wave and ultrasound waves
- Meaning of regions of whit (Hyperechoic), light dark (Hypoechoic) and black (Anechoic) regions in the ultrasound image.

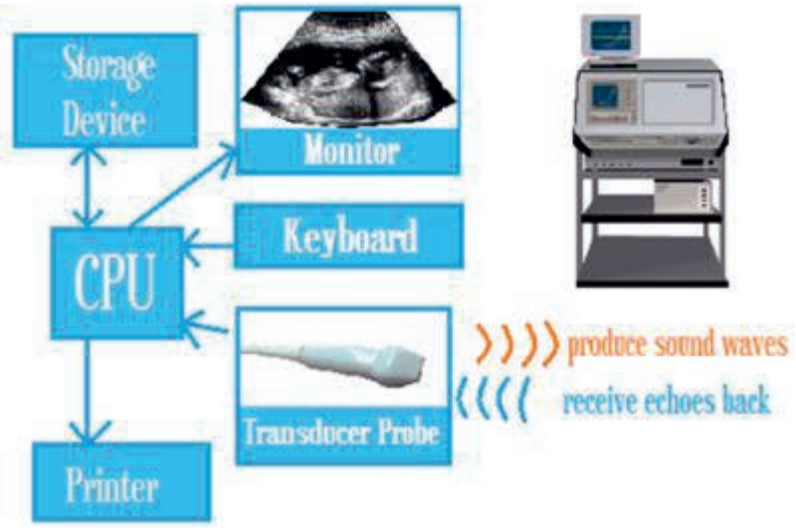



Figure 1.5: Major parts of an ultrasound machine and workflow

**Radiation Therapy**

Dear teacher, start this subsection by asking the first question of Brainstorming question 1.12. Give a couple of minutes to reflect on this question.

Then ask them the second question of Brainstorming question 1.12 and let the third group present what they have understood from their homework reading and class room discussion on ~~–r~~adiation therapy". Shape their reflation in relation to the concepts mentioned under this sub-section and the answer to Brainstorming question 1.12 below.

**Brainstorming question 1.12: Answer**

Radiation Therapy (irradiation or radiotherapy) is the use of high energy radiation, primarily x-rays, to kill cancer cells. In high doses, radiation causes damage to cells by interfering with the cell's ability to grow and reproduce. Cells that are growing and multiplying are very sensitive to the effects of radiation. Because cancer cells reproduce more frequently than normal cells, they are more likely to be damaged by radiation. Normal cells can also be affected by radiation, but normal cells tend to be able to recover from radiation damage. This treatment could be made in two ways without surgy:

**External beam**: an external beam radiation therapy machine outside your body aims the radiation at your cancer cells through your skin.

**Internal or brachytherapy**: In the treatment of certain types of cancer, an ampul containing radioactive material such as radium or cobalt 60 is implanted near the cancerous growth. By careful placement of the radioactive material and by controlling the dose, it can destroy the cancer without greatly damaging the healthy tissue.

**Summary**

An X-ray imaging (both conventional and CT scan) is based on the absorption of X-rays as they pass through the different parts of a patient's body.

During a regular X-ray procedure, a stationary machine sends X-rays through the body to make a single shadow picture. A computerized tomography (CT) scan or also known as computerized axial tomography (CAT) scan uses computers and rotating X-ray machines to create cross-sectional images (called tomograms) of the inside of body.
Stethoscope and ultrasound use sound wave to diagnose body parts. Stethoscope is used direct listening of sound from body parts whereas ultrasound forms visual images.
In controlled doses, radiation can be used therapeutically either internally or externally

**Assessment**

(i) What physics principle is used in conventional X-ray and CT scan?
(ii) What physics concept is used in ultrasound and stethoscope?
(iii) Explain how radiation is used for therapeutical purpose.

## 1.4. Physics and defense technology

This section should be completed approximately in 1 periods of teaching time.

**Introduction**

Start this section asking students to list as many defense technologies possible and their purpose. Give them some motivating hints if they have difficulty to mention some. Feedback them as per their reflection. Raise also Brainstorming questions 1.13, 1.14 and 1.15. Feedback them as per their reflection and the guiding answer for these Brainstorming questions below. Then state the specific objective of this section as stated in the students‘ text book.

**Brainstorming question 1.13: Answer**

Physicists in military science conduct researches in a variety areas of physics like lasers, electro-optics, semiconductors, materials science, aerodynamics, etc. The findings of the research are directly applied in the advancement of the defense technology.

**Brainstorming question 1.14: Answer**

Air traffic controllers monitor the location of aircraft in their assigned airspace by radar and communicate with the pilots by radio. To prevent collisions, Air traffic controllers enforces traffic separation rules, which ensure each aircraft maintains a minimum amount of empty space around it at all times.

**Brainstorming question 1.15: Answer**

Night vision is the ability to see in low-light conditions i.e., at night or in the presence of smoke, fog or at dusk. Humans have poor night vision compared to many animals such as cats. Humans demand the aid of night-vision devices to see objects at dark night or low-light conditions. The basis of night vision device is to collect and amplify the very weak light of the moon, stars or external infrared illumination many times. This amplified light helps to see the object at low light conditions.

**Presentation**

Classify the students into three groups. To discuss on Radar, missile and infrared-detection for night vision.

**Radar**

Tell the group one students to read about Radar in their text book to answer the following questions:

(a) What are the purposes of radar?
(b) How a radar detects a target around it?
(c) What basic sets of components are required in radar system?
(d) What component of radar is a signal generator and receiver?
(e) Ask them to derive the range of the target:

$$\text{speed} = \frac{\text{distance}}{\text{time}},\ \text{distance} = \text{speed} * \text{time};\ 2R = c * t \text{ and } R = \frac{ct}{2}.$$

Give them 5 minute to read and response. Then feedback the students‘ reflection.

Summarize the radar discussion as follow:

- Radar detects a target by sending a radio wave and receiving the reflected wave from the target
- A radar system has such components as: a magnetron to generate radio waves, antenna to send them out into space and also to receive them, and screen to display.
- A radar system uses a relation $R = \frac{ct}{2}$, to determine the distance of the target where R is a distance, c is speed of light, t is time taken by the radar wave for transmission from the source to the target and reflect back to the radar.
- Radar system can be used in defense and air traffic controlling.

**Discussion question 1.7: Answer**

The basic principle behind radar is simple - radio wave energy, traveling at the speed of light are transmitted, reflected off a target and then returned as an echo. Radar makes use of the echo principle.

**Missile**

Tell the group two students to read about missile to answer the following questions:

(i) What is a missile?

(ii) How can a missile be propelled to the target?

(iii) What is the difference between ballistic and cruise missile?

Give appropriate feedback and reward for students‘ response and summarize the missile reading and discussion as follow:

- A missile is a weapon propelled by either a rocket or a jet.
- Cruise missiles are jet-propelled throughout their flights. Ballistic missiles are rocket-powered only in the initial phase of flight.
- There is continuous radio communication between the internal missile controlling unit and the launch controller to track the target and the proper functioning of each unit of the missile.

**Infrared detection for night vision**

Tell group three students to read about infrared detection for night vision to answer the following questions:

- What is the importance of infrared detecting devices?
- What affects the radiation of infrared by any object?
- How infrared device detect object at low light condition?

Give appropriate feedback and reward for students‘ response and summarize the infrared wave detection for night vision reading and discussion as follow:

- All people, places, and things give off infrared light in an amount proportional to their temperature
- Infrared devices will typically use heat emissions to identify objects that cannot be detected using available light sources.
- Thermal imaging systems create an electronic image based on the temperature differences in the radiating object; hotter objects appear brighter than cooler objects.
- Temperature difference in the target is represented by different colors that are not related to the actual color of the target.

**Assessment**

- Explain working principle of radar and infrared wave detection devices.
- If a radio wave sent to the target from a radar takes 0.5 ms to return back, how far is the target?
- What physics knowledge is used in radar, missile and infrared wave detection for night vision system?

**Discussion question 1.8: Answer**

The basic physics concepts in radar are transmission and reflection of electromagnetic wave, echo principle and some knowledge of optics, lenses or telescope, and electronics for observation. In the case of infrared wave detection, the basic physics includes thermal physics, optical physics and electromagnetic wave transmission and reflection.

**Activity 1.4 Homework**

Dear teacher, make an arrangement for students‘ visit to a nearby military establishment. Facilitate official letter from the school to the military establishment. Tell students how to proceed the visit.

Notice that military establishments are strict at rule. Group the students in way convenient to the visit. The students should prepare a visit report. The report is about instruments and methods applying physics in the establishment. One student from each group can present their report. Encourage the students for class discussion on the presented report.

## 1.5 Physics in communication

This section should be completed approximately in 1 periods of teaching time.

**Introduction**

Start this section asking students Brainstorming question 1.16 to list all the communication technologies they have ever used and the physics concepts these technologies used? Dear teacher, encourage students to mention the communication technologies they have been using. Student may mention like: telephone, radio, television, internet, etc. Ask them to explain any physics concept that these technologies are applying.

Give them about 3 minutes to complete their response and then feedback them accordingly. Then state the specific objectives of this section as stated in the students‘ text.

**Presentation**

Discuss the following using question and answering method:

- What communication mean
- the purpose of medium of communication
- components of electromagnetic wave that can be used for communication
- the difference between wired and wireless communication supporting by examples
- Explain how different physics knowledge are used in communication technology

**Summary**

Summarize this section as follow:

- Communication is transferring of information from one point to another using wire or without wire

- Most of the communication technology uses the electromagnetic radiation physics like Reflection, refraction, diffraction, interference, rarefaction, propagation, transmission and compression.
- Fiber optics uses the law of complete internal reflection of light.
- Wireless communication needs no wire however wire communication demands wire or fiber optics cable.

**Assessment**

(i) What basic physics concepts are important in communication technologies?

(ii) What is the purpose of communication satellite?

(iii) What component of electromagnetic wave is used in satellite communication and wireless communication?

**Discussion question 1.9: Answer**

The transmitter takes information like audio or video, stores it into a sine function, and transmits the function into the air in the form of an electromagnetic wave. Since the electromagnetic wave travels in vacuum, the message stored in the electromagnetic wave as a sine function also need no medium for transmission. The receiver detects the wave and take out information from its storage in the sine function.

**Home work**

1. Dear teacher give students a homework to prepare a brief working principles of the following communication technologies: (i) radio; (ii) television; (iii) internet; (iv)mobile;(v) satellite.
2. Dear teacher, organize your students in a group of 5 to evaluate grade 11 Biology, chemistry, IT, agriculture and one of your subject specialization based text books. Distribute the five subjects in to the groups by lottery system. Each group has to identify what physics concepts and physics concept-based technologies available in each of the subject text book. Each group should submit the findings.

# UNIT 2

# TWO-DIMENSIONAL MOTION

This unit should be completed approximately in 21periods.

**Brainstorming Question 2.1 Answer**

1) According to Newton's first law of motion, such a ball would continue in motion in a straight line at constant speed. The ball does not change its direction unless acted upon by any other external unbalanced force. This motion is called uniform motion along a straight line.

2) The ball will fall in an arc towards the ground. Gravity causes a vertical acceleration. Gravity influences the ball‘s vertical motion and causes the parabolic trajectory(arc) that is characteristic of projectiles. There are no horizontal forces acting on the ball. Therefore, the horizontal velocity of the ball is constant (i.e. constant velocity). The only force acting upon a projectile (in this case, the ball) is gravity.

## 2.1 Projectile motion

This section require approximately 6 periods

**Introduction**

Students learned about one- and two-dimensional motion in Grade 11. This section extends the coverage of two-dimensional motion by looking at projectile motion. Revise the concept of two-dimensional motion with the students. Many students have difficulty with the concept that the only force acting upon projectile is gravity. Students think that if an object is moving forward there must be a forward force. Remind students that horizontal forces are not required to keep a projectile moving horizontally. The horizontal motion of the projectile is the result of motion at constant velocity (Newton‘s first law). Gravity acts to influence the vertical motion of the projectile, thus causing a vertical acceleration.

Read through the minimum learning objectives with students.

**Presentation**

Discuss the concept of horizontal projection and inclined projection. The horizontal and vertical components of motion are independent of each other. Then let students to discuss the discussion questions from 2.1 to 2.5 in group Derive the general equations for horizontal and inclined projectile motion like vertical displacement, vertical velocity, and horizontal displacement, and time of flight. While you are doing the derivation of the equation discuss each step with students. Do the worked examples with students. Give exercise 2.1 as a class work. Demonstrate horizontal and inclined projectile motion using the Activities from 2.1 to 2.4 In this demonstration activities, group the students in small group and let them carry out the activities Groups should then report back their finding to the rest of the class.

**Discussion Question 2.1 Answer:** Choice d) A bird flying in the air

The motion of a bird flying in the air is not projectile motion. This is because atmospheric pressure exerts an upward force (lift) which supports the bird, and thrust (a forward force) help them to move forward by Newton‘s third law. However, the only force acting on projectile motion is gravity.

**Horizontal Projection**

Ask students to give examples of horizontal projection. Discuss with students the initial velocity does not make angle with the horizontal.

**Equations of horizontal projection**

Dear teacher do the derivation of equations with students. These equations are used to calculate vertical motion quantities like: vertical displacement, vertical velocity and time of flight. Do the same for the horizontal displacement (Range) and horizontal velocity from the horizontal motion. Discuss with students while you are solving the worked examples. Give additional problems from end unit problems as a class work and home work. Assists them if they have any difficulties of doing their class work or home work.

**Discussion question 2.2 Answer**

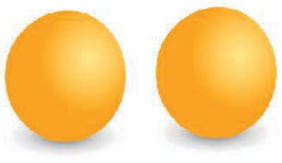
This is a type of horizontal projectile. When the package is dropped, it has a horizontal initial velocity equal to the horizontal velocity of the aircraft. Thus, it performs horizontal projectile motion. As the package hits the ground at the village, the aircraft travels the same horizontal

distance as the package. Because the aircraft is travelling with a constant velocity so both have the same horizontal velocity. Therefore, at the moment the package hit the ground the aircraft is found vertically above the package.

**Activity 2.1**

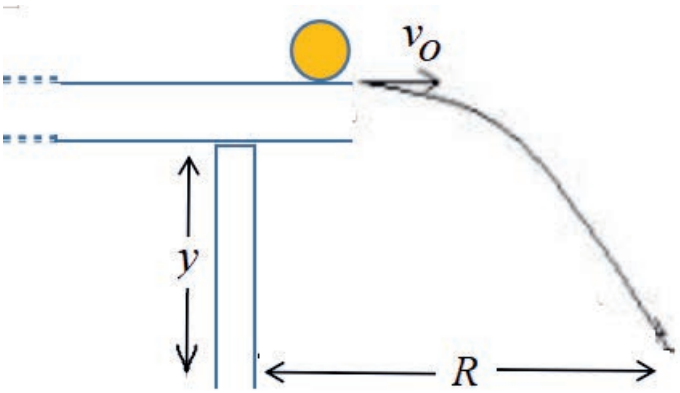
Dear teacher assist students to carry out Activity 2.1. This activity helps students to easily understand horizontal projection. Equipment required per group of students:

- two tennis balls
- ruler or tape measure.



Tennis ball

Ruler




a) Both the tennis balls perform horizontal projectile motion. Regardless of the initial velocities both tennis balls have the same initial velocities. This is because the vertical displacement is the same for both that is the height of the table. We use the relation.

$$\Delta Y = \frac{1}{2} gt^2$$

$$t=\sqrt{\frac{}{}}$$

b) We can calculate the initial horizontal velocity for each tennis balls from the measurement of the Range.

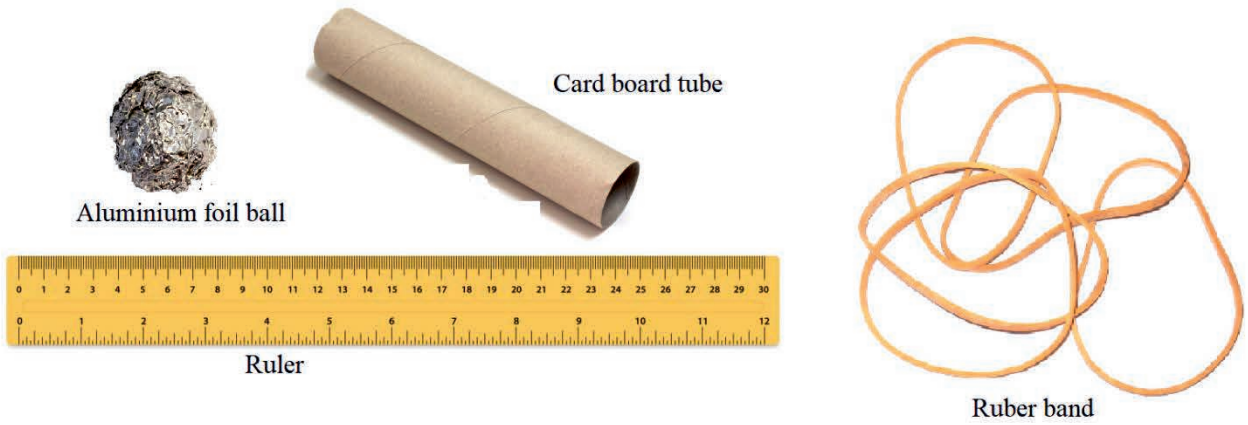
$$R_1 = V_{0x1}\, t \quad \text{and} \quad R_2 = V_{0x2}\, t$$

$$v_{0x1} = \frac{R_1}{t_1} \qquad\qquad v_{0x2} = \frac{R_2}{t_2}$$

**Activity 2.2**

Dear teacher assist the students to perform this activity. In this activity the students learn the relation between initial horizontal velocity and range of the projectile. The initial velocity can be increased by increasing the stretching of the rubber band. The students learn the range is directly proportional to the initial velocity.

The materials needed to perform this activity are easily available in your surroundings as shown below.



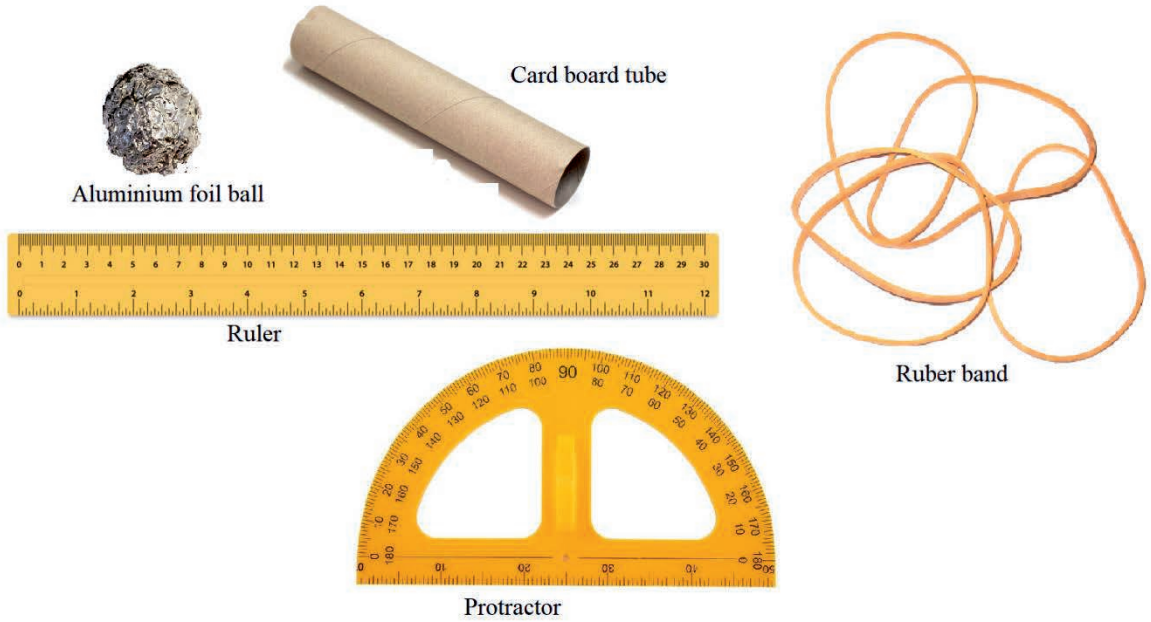

**Inclined projectile motion**

Dear teacher ask students what inclined projection mean, also its difference from horizontal projection. Ask them to give examples of inclined projectile motions. Discuss the derivations of the vertical and horizontal equations of motion with students. These

equations are applied to solve problems related to vertical displacement, vertical velocity, horizontal displacement, horizontal velocity and time of flight. Discuss with students while you are solving the worked examples. You may need to do some additional examples with the students. You can select problems from end chapter problems. Give additional problems from end chapter problems as a class work and home work. Assist them if they have any problem of doing their class work or home work.

**Activity 2.3**

Dear teacher Assist the students in performing this activity. If you keep the stretching of the rubber band constant then the initial velocity is constant. Use the protractor to vary the angle of projection. By using a ruler you can measure the the range and maximum height of the ball. Then the students can easily find the relation between angle of projection, range and maximum height reached by the projectile. The materials are easily acvailable in your surrounding as shown below.




**Horizontal Range and Maximum Height of a Projectile**

Dear teacher discuss about the three equations listed below are valid for launch and impact on the same horizontal level as shown in Figure 2.5 in the text book. This situation

is common in sports, where baseballs, footballs, and golf balls often land at the same level from which they were launched.

We see from the factor of sin2θ two angles sum to $90^0$ have the same range. Furthermore, we see from the factor sin2θ that the range is maximum at 45°.

$$t_{total} = \frac{2V_0 \sin\theta}{g}$$

$$R = \frac{V_0^2 \sin 2\theta}{g}$$

$$H = \frac{V_0^2 \sin^2\theta}{2g}$$

Give additional problems from end chapter problems as a class work and home work. Help them if they have any difficulty of solving these problems.

**Discussion Question 2.3 Answer**

The relation between angle of projection with maximum height and horizontal range is demonstrated in Figure 2.5b in the text book. When the angle of projection increases the maximum height increases.

a) If the angle of projections of two balls sum to $90^0$ the horizontal range is the same
b) As the angle of projection increases, the height also increases. Thus, the ball with $53^0$, travels the maximum height.

You can verify these by maximum height and horizontal range formula.

$$R = \frac{V_0^2 \sin 2\theta}{g} \quad \text{and} \quad H = \frac{V_0^2 \sin^2\theta}{2g}$$

**Discussion Question 2.4 Answers**

1. Given: R=3H

$$R = \frac{V_0^2 \sin 2\theta}{g} \quad \text{and} \quad H = \frac{V_0^2 \sin^2\theta}{2g}$$

R=3H

$$\frac{V_0^2 \sin 2\theta}{g} = \frac{3V_0^2 \sin^2 \theta}{2g}$$

Use the trigonometry relation $\sin 2\theta = 2\sin\theta\cos\theta$

$\tan\theta = 4/3$

$\theta = \tan^{-1} 4/3$

$\theta = 53^0$

2. (c) Its velocity is perpendicular to its acceleration.(Ref. fig.2.5 in the text book)

3. Both reach at the same time as they are covering the same height.

**Relation between Range and maximum height.**

Dear teacher you can combine the Range and maximum height formula as it is done in the students' text and obtain, = ——— . But this equation does not apply when the projectile lands at a different elevation than it was launched.

Help students to solve related problems by using this equation.

**Activity 2.4**

Dear teacher in this activity the initial velocity can be determined from the law of conservation of mechanical energy by neglecting friction force. By measuring the angle the horizontal range and and maximum height can be determined. Compare the the value of the range you obtain by the measurement and calculation. The small difference is due to the different types of source of errors.

**Discussion question 2.5 Answers**

1.

a) At maximum height the only velocity is in the horizontal direction. This velocity is perpendicular to the acceleration due to gravity.

b) There is no any point along the path where the velocity and acceleration vectors are parallel to each other?

2. Answer: e) All are true
3. Both the range and maximum height vary inversely with acceleration due to gravity. Therefore, the projectile fired on the moon has the greater range and height.

**Summary**

Summarize this section by reminding the following concepts:

- The only force acting on projectile motion is gravity and this force produces vertical acceleration due to gravity.
- The horizontal motion is a constant velocity motion. This motion is explained by Newton‘s first law of motion.
- The vertical and the horizontal components are independent to each other.
- For horizontal projectile motion the angle of projection is zero i.e the initial velocity does not make an angle with the horizontal.
- The horizontal and vertical components are independent to each other. The time of flight is common for both horizontal and vertical motion.

**Assessment**

Dear teacher select questions from exercise 2.1 and end unit problem as class work and home work and provide feedback.

Ask questions about the following concepts of projectile motion:

- The vertical acceleration.
- The horizontal acceleration.
- The vertical component of the velocity at the maximum height.
- How the vertical velocity component varies with time.
- Trajectory
- Draw the trajectory and show the components of the velocity at each point on the trajectory.

**Exercise 2.1 Answers**

Solution:

1) The velocity is minimum at maximum height because there is only horizontal velocity at this height.

2)

Vox=500m/s

x=50m

The equation for the horizontal displacement is:

$x = v \quad t$

$50m = 500\ m/s \times t$

$t = 0.1s$

The equation for the vertical displacement is

$y = -gt$

$y = -(-10m/s2)$

y=-0.05m=-5cm (The negative sign indicates the displacement is vertically downward.

Therefore the gun should be aimed 5cm above the target.

3) a)

$-90m = -x(-10m/s2)\ )x\ t$

t=4.2s

b)

$x = 20m/s \times 4.2s$

$x = 84m$

C)

$v = gt$

$v = -10m/s2 \times 4.2s$

$v = -42m/s$

$v = \sqrt{\qquad}$

$v = \sqrt{\qquad\qquad\qquad\qquad}$

V=46.5m/s

4)

The horizontal range is: $R = \frac{V_0^2 \sin 2\theta}{g}$

R = ————

R = 7.77m

The maximum height reached $H = \frac{V_0^2 \sin^2 \theta}{2g}$

$$H = \frac{(11)^2 \sin 20^0 \sin 20^0}{2x10}$$

H = 4.13m

5)

t=————

Sinθ=0.5

θ=300

R= v cosθt

t is the total time which 2x1.5s=3s

R=30m/sxcos30x3s

R=90mx0.87

R=78.3m

## 2.2 Rotational Motion

This section requires approximately 6 periods

**Introduction**

Dear teacher revise with students what they already know about circular motion. This section discusses rotational motion of a rigid object about a fixed axis. Introduce the term axis of rotation. Any object moving in a circle moves about this axis of rotation. Introduce the concept rigid body as it is defined in the student text book. Ask students to give

example of rotational motion. Help students make the link between linear and angular quantities. State the specific objectives of this section.

**Presentation**

**Angular displacement and angular velocity**

**Angular Displacement($\Delta\theta$)**

Define angular displacement. Discuss the possible units of angular displacement. Discuss the relation between angular displacement and linear displacement.

**Angular Velocity($\omega$)**

Define angular velocity. Discuss the relation between angular velocity and linear velocity using Figure 2.7, in the student text book. The three particles A, B, and C have the same angular velocity but different linear velocity. The linear velocity depends on the radius of position of the particle from the axis of rotation. Ask students to discuss about the time rate of change of angular position, and define it as average angular velocity ( —) Solve problems using this equation.

**Angular Acceleration**

Define angular acceleration. Discuss the relation between angular acceleration and linear acceleration. The linear acceleration depends on the radius of position of the particle from the axis of rotation. Discuss with students the time rate of change of angular velocity, and define it as average angular acceleration ( —). Solve problems using these equations.

**Direction of angular velocity and angular acceleration**

**Discussion question 2.6 Answer**

Figure 2.10 in the student text book illustrates the right-hand rule for determining direction of angular quantities. When the four fingers of the right hand are wrapped in the direction of rotation, the extended right thumb points in the direction of $\omega$. The direction of $\alpha$ follows from its definition $\alpha = \Delta\omega / \Delta t$. It is in the same direction as $\omega$ if the angular speed is increasing in time, and it is antiparallel to $\omega$ if the angular speed is decreasing in time.

**Equations of Motion in Uniform angular motion**

Discuss with students the derivation of the equations of angular motion. In this equation the angular acceleration is constant. Go through the worked examples. You may need to do some additional examples with the students. Give class work and home work from the end chapter problems and help them if they have any difficulty in solving the problems.

**Kinematic Equations for Rotational and Translational Motion**

Revise what the students know about uniformly accelerated motion in a straight line. Discuss the equations of motion in uniform angular motion which has the same form as the linear motion with constant linear acceleration. The comparison is listed in Table 2.1 in student text book. Go through the worked examples. You may need to do some additional examples with the students. You can select problems from the end chapter problems.

**Relationship between Angular and Translational Quantities**

Dear teacher discuss with students the translational quantities of a rotating particle are related with its counterpart of angular quantity by multiplying with radius. Go through the worked examples. Help students to solve related problems. Ask students to carry out Question 2.2 in the student text book.

**Discussion Questions 2.7 Answers**

1.

For one complete rotation t = period = 60s

The angular displacement is $\Delta\theta = 2\pi$ rad

$\omega = 0.104$ rad/s

The rotation is clockwise, assuming the clock is hanging on a wall, by the right hand rule the direction of the angular velocity is into the wall,

2. Apply right hand rule, direction of is out of the xy plane and direction of into the xy plane since it is negative.

3. They have the same angular speed but the linear speed depends on radius of the particles from the axis of rotation.

**Summary**

Summarize this section by reminding the following concepts:

Rotational motion is the motion of objects about a fixed axis.

All the particles under rotational motion have the same angular velocity and angular acceleration.

The linear velocity and liner acceleration of the rotating particles depend on the radius.

The equations of motion with constant angular acceleration has the same form as the equation of motion with constant linear acceleration along a straight line.

**Assessement**

Dear teacher select questions from exercise 2.2 and end unit problems as homework and class work, and provide feedback.

Ask questions on the following concepts:

- Axis of rotation
- Rigid body
- Radian
- Angular displacement, angular velocity and angular acceleration.
- Linear displacement, linear velocity and linear acceleration.

**Exercise 2.2 Answer**

1) True (All particles on the wheel have the same angular speed and angular acceleration.)

2) D. (rpm is the unit of angular speed).

3)

r=20cm, s=10 m, t=5s

=——=———=50 rad

= —— ——— = 10 rad/s

4)

$= = = 1.67$ rad $= 95.7$ degree

5)

$=$

$= = 0.9$rad

6)

Convert rpm into rev/s

$=$

$= = 60$rev

## 2.3 Rotational Dynamics

This section requires approximately 2 periods

**Introduction**

Revise with students what they already know about rotational dynamic in grade 10. Students know how to calculate when the force is force is perpendicular to the moment arm. In this section they will learn torque produced for different angle of the force with the moment arm. The relation between net torque and angular acceleration will be discussed. State the specific objectives of this section.

**Presentation**

Ask them to define torque and moment of inertia. Discuss moment of inertia.for a point mass and collection of point masses. Discuss the relation between net torque and angular acceleration. Do the worked examples with students . Give exercise 2.2 as a class work or home work.

**Summary**

Summarize this sub section s by reminding the following points:

Torque is a rotational effect of force. Moment of inertia is a measure of rotational inertia of a body. Net torque is directly proportional to angular acceleration.

**Assessement**

Dear teacher give homework and class work by selecting questions from exercise 2.3 and end unit problems.

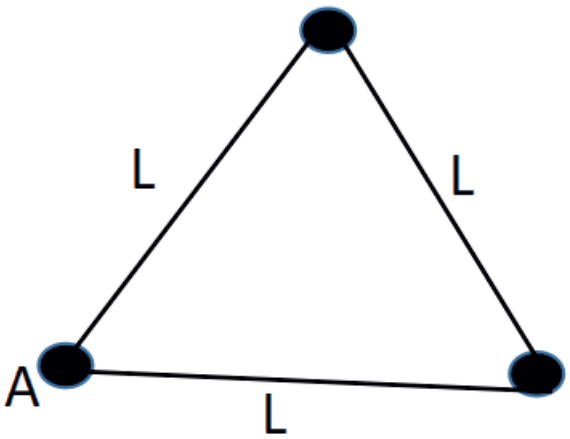
Ask questions on the following concepts:

- Torque
- Moment of inertia
- Torque and angular acceleration.

**Exercise 2.3 Answer**

1) $\tau=Fr\sin\theta \quad \theta=150^0$

$\tau=400Nx\ 5m\ \sin1500=1000Nm$




2)

Let us choose axis of rotation through A, Therefore, the moment of inertia of mass at A is zero only the other masses produce moment of inertia about A.

$$I = mL^2 + mL^2 = 2mL^2$$

3)

$\alpha = \frac{\quad}{\quad} = \frac{\quad}{\quad} = 25 rad/s2$

$t = \frac{\quad}{\quad} = \frac{\quad}{\quad} = 0.25s$

## 2.4 Planetary motion and Kepler's Laws

This section requires approximately 4 periods

**Introduction**

This motion is a type of curvilinear motion. The path of the motion is called orbit. Revise this section from what the students already know about circular motion. Ask them about orbit of a planet. Discuss the three laws of Kepler. State the specific objectives of this section.

**Presentation**

**Kepler's first law**

State Kepler's first law. Ask students the difference between circle and ellipse. Discuss with students about shape of orbit of a planet. Ask them which planet has the smallest orbit. Let students to discuss discussion activities 2.5. Ask students the position of the sun in the orbit. Go through the worked example. You may need to do some additional examples with the students.

**Discussion Question 2.8 Answer**

- An orbit is path described by one body in its revolution about another (as by the earth about the sun or a planet about the sun, an electron about an atomic nucleus).
- An orbit is a curved path, like a circle or an ellipse Some planets have long orbit and other have short orbit.

- Most Massive object is at the center of an orbit: The Sun is the center of our solar system, the Earth is the center of natural and artificial satellites, the nucleus is the center of orbital electrons.
- An ellipse is a squashed circle. The radius of a circle is constant, but not radius of ellipse.

**Kepler's second law**

State Kepler's second law and discuss with students as it is illustrated in Figure 2.20 in student text book Let students to discuss discussion question 2.9. Go through the worked example. Discuss the perihelion and aphelion positions of a planet and their significance to explain the speed of the planet at different position of the orbit.

**Discussion Question 2.9 (Answers)**

Planet is moving fastest when it is at perihelion and slowest at aphelion. At perihelion the planet is closer to the sun than aphelion, the gravitational force (centripetal force) is greater at perihelion than aphelion.

**Kepler's Third law**

State Kepler's third law. Discuss with students Kepler' third law. Let students to discuss discussion question 2.10. Ask students the meaning of period of a planet and relationship between period and radius of the planet. Solve the worked examples with students. You may need to do some additional examples with the students.

**Discussion question 2.10 Answers**

- The period of the earth is one year.
- The time taken to complete one revolution.
- The earth has the shortest orbital period because is close to the sun than Pluto.
- By Kepler's third law the ratio — is constant. The constant is the same for all planets

**Summary**

Summarize this sub section s by reminding the following points:

Kepler's first law, Kepler's second law, Kepler's Third Law.

The speed of the planet increases as it nears the Sun and decreases as it recedes from the Sun.

The period for a planet to orbit the Sun increases rapidly with the radius of its orbit.

**Assessment**

Dear teacher give home work and class work by selecting questions from excersis 2.4 and end unit problems and provide feedback.

Ask questions on the following concepts:

- Orbit of a planet
- Period of a planet
- perihelion and aphelion.
- The Kepler‘s three laws
- The speed of planets along their orbit.

**Exercise 2.4 Answer**

1) True (The planets have different speed at different position of their orbit.When they are closer to the sun the gravitational force increases because the distance of the planet from the Sun decreases).

2)

$$\frac{}{} \quad \frac{}{}$$

$$\frac{}{} \quad \frac{}{}$$

Ts = 0.672 days

3)

You can answer this question by using the relation Kepler‘s third law:

$$\frac{}{} = K$$

Answer c) The period would increase by a factor of $2\sqrt{2}$

## 2.5 Newton's law of universal gravitation

This section requires approximately 3 periods

**Introduction**

Every year, Earth finds its way around the Sun. This happens without fail, and the same happens with the other planets in our solar system. There's nothing physical connecting the planets to the Sun. This section discusses how planets stay in orbit instead of flying off into space.

**Presentation**

State Newton's universal law of gravitation. Discuss the mathematical expression of the law. Let the students discuss the discussion Questions 2.11 and 2.12. Ask what keeps the planets in orbit and what would happen to them if the sun gravity were suddenly switched off. Discuss the relationship between orbital period and distance between a planet and the sun ( —— ). Solve simple problems using eq. —— . Go through the worked examples. Give homework and class work and provide feedback.

**Discussion Activity 2.11 (Answer)**

Isaac Newton first explained how planets orbit the Sun and how the Moon orbits Earth. He explained that gravity is a key aspect in keeping the planets in orbit. The Sun's gravity constantly pulls on the planets, preventing them from leaving their orbit and the solar system. The forward motion of the planets prevents the Sun's gravity from pulling planets straight into it.

**Brainstorming question 2.2 Answer**

If the Sun gravity is suddenly switched off, the planets would move in a straight line with a constant velocity (Newton's first law). They no longer follow their elliptical path. Because it is the gravity of the sun that changes their path so that they follow the elliptical orbit.

**Discussion Activity 2.12 (Answers)**

i) Volume of the earth is given by the relation $-\pi r3$ , assuming it has a shape of sphere. To change its volume by a factor of eight, the radius should be doubled.

From this relation when the radius is doubled, the weight decreases by a factor of –

ii) ——

From this relation when the mass of the earth is decreased by one-third, the weight of the person decreases by a factor of –.

**Summary**

You can Summarize this section by reminding the following points:

- State Newton‘s Universal law of gravitation as stated in the students text book.
- The universal gravitational constant works for every mass and everywhere.
- Plants are kept about their orbit by the gravity of the Sun.
- Kepler‘s third law can be proved by using Newton‘s gravitation law.

**Assessment**

Dear teacher select questions from exercise 2.5 and end unit problems, and give home work and class work. Provide feedback for each question.

Ask the following conceptual questions.

- State Newton‘s Universal gravitation.
- Derive Kepler‘s third law from Newton‘s gravitation law.
- Apply the derived equations to solve related problems.

**Exercise 2.5 Answer**

1) False (The force between two masses is action and reaction force, therefore they equal and opposite)

2) B. 1/4F (Gravitational force is inversely proportional to the square of the the distance between the masses.)

3) C. All bodies irrespective of their masses

4) F=120N(Gravitational force is directely proportional to the product of the masses.)

5)

— —— $2.97x10\text{-}19s2/m^3$

———————— 1.989x1030kg

6) The acceleration due to gravity is directly proportional to the mass of the planet and inversely proportional to the square of the radius of the planet. From this mathematical relation, the hypothetical planet has the same acceleration due to gravity as the earth.

## Answer for the unit end questions

1) **Solution:**

a) $\Delta Y = \frac{1}{2} gt^2$

$t = \sqrt{\quad}$

$t = 3s$

b) $\Delta x = v_{0x}t$

$\Delta x = 30m/s \times 3s = 90m$

c) $V_y = -gt$

$Vy = -10m/s \times 3s = -30m/s$

$Vx = 30m/s$

———— 42.42m/s

2) a) $V_{ox} = V_o Cos\theta$

$V_{ox} = 20m/s \times cos30^0$

$V_{ox} = 17.4m/s$

$V_{ox} = V_o Sin\theta$

$Vox = 20m/s \times 0.5 = 10m/s$

b) $t = \frac{2V_0 \sin\theta}{g}$

$t = \frac{2x20m/sx0.5}{10m/s}$

$t = 2s$

c)

$R = \frac{V_0^2 \sin 2\theta}{g}$

$R = \frac{(20)^2 \sin 60^0}{10}$

$R = 34.8m$

d) $\Delta X = V_{ox}t = V_o cos\theta t$

$\Delta X = 20m/s \times 0.87 \times 1s = 17.4m$

3) **Solution**

$Vo = 5Vocos\theta$

$Cos\theta = 1/5$

$\theta = \cos^{-1} 1/5 = 78.46^0$

4) The vertical displacement is: $\Delta y = V_o \sin\theta t + -gt^2$

$-3300 = V_o \sin 35^0 \, t + -(-10) \, t^2$

$-3300 = Vo \times 0.573 \, t + -(-10) \, t^2$

$-3300 = Vo \times 0.573 \, t - 5t^2$

From the horizontal displacement

$\Delta x = V_o \cos\theta t$

$\Delta x = V_o \cos 35^0 \, t$

$9400 = V_o \times 0.82t$

$9400 = 0.82 V_o \, t$

By combining the two equations (from horizontal and vertical displacement)

You can get the initial speed and time of flight

Thus, $V_o = 258.2$m/s and $t = 44.46$s

5) **Solution**

$d = 24$m

$\theta_i = 53^0$

$V_i = 20$m/s

$\Delta X = V_0 \cos\theta t$

---

---

$t = 2$s

$h = V_0 \sin\theta t + -gt^2$

$h = 20\text{m/s} \times 0.8 \times 2\text{s} + -(-10\text{m/s}) \times (2\text{s})^2$

$h = 12$m

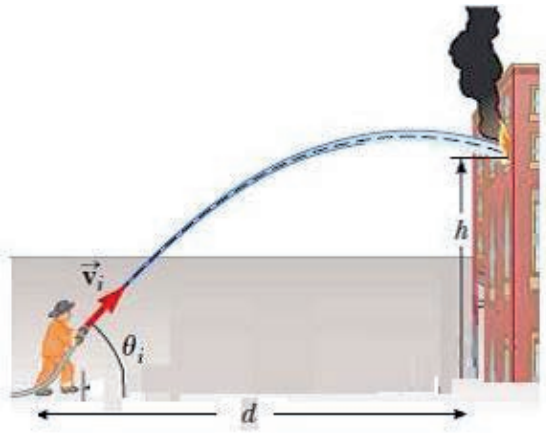



Fig.2.22 A firefighter directs a stream of water from a fire hose.

$\Delta y = V_o \sin\theta t + -gt^2$ , g is negative.

$h = V_i \sin\theta_i t - t^2$

6) A rotating fan completes

**Solution**

$\Delta\theta = 1200\text{rev} = 7536\text{rad}$

$r = 0.15\text{m}$

$t = 1\text{minute} = 60\text{s}$

a) $S = r\Delta\theta = 0.15\text{m} \times 7536\text{ rad} = 1130.4\text{m}$

b) V = - = ——— =18.84m/s

7) A car traveling

**Solution**

$V_o = 80\text{km/h} = 22.2\text{m/s}$

$\omega_o =$ – = ———

$V_f = 0$

$\omega_f = 0$

$r = 40\text{cm} = 0.4\text{m}$

$\Delta\theta = 30\text{rev} = 188.4\text{ rad}$

$\alpha = ?$

$$\omega_f^2 = \omega_0^2 + 2\alpha\Delta\theta$$

$$\frac{\omega_f \ \omega}{\theta}$$

$-8\text{rad/s}^2$

8) The angular

t =1minute

$\Delta\theta$ =?

$\Delta\theta = \omega t$

a) $\Delta\theta$ =4 0rad/sx60s

$\Delta\theta$ =2400rad

b) 1rev = 2πrad

$\Delta\theta$ =382rev

c) $\Delta\theta$ =137,579.6$^0$

9) A cyclist rides a

r = 0.5m

$\Delta\theta$ = 320rev

S = $\Delta\theta$r

S = 0.5m x 320 x 2πrad=

1004.8m

10) A spinning wheel is

$\alpha$ = -5.60rad/s$^2$

t = 4.20s

$\Delta\theta$ = 62.4rad

$\omega_f$=?

$\Delta\theta$ = $_o$t+ –

By substitute you can get the initial angular velocity.

$\omega_o$ = 26.6m/s

$\omega_f = \omega_o + \alpha t$

$\omega_f$=26.6rad/s-5.6rad/s$^2$x4.2

$\omega_f$ = 3.08rad/s

11) Titan, the largest moon

$_t$ = 15.95

$_t$ = 1.22 10$^9$

$_h$ = 1.48 10$^9$

$_h$ =?

**Solution**

$\frac{t}{t}$ $\frac{h}{h}$

$\frac{}{x \quad m}$ $\frac{h}{x \quad m}$

To solve for $T_h$, we cross-multiply and take the square root.

Thus: $_h$ = 21.3

12) The planet Mercury

$2.97 \times 10^{-19} s^2/m^3$

$2.97 \times 10^{-19} s^2/m^3$

T = 0.241year =88.1dayes

13) Two identical isolated

$$F_g = 2.96 \times 10^{-9} \text{ N}$$

# Unit 3: Fluid Mechanics

This unit should be completed in approximately 21 periods.

**Introduction**

- Ask students what the three states of matter are
- Ask them also what fluid mean and what is the difference between fluid and solid
- Pose the following brainstorming questions:

Brainstorming question 3.1

1. Why over inflated balloon bursts?
2. How a plane moves up against gravity?

After listening few students‘ response on the brainstorming questions, feedback them by simply the phenomena raised in the first brainstorming question is due to outward pressure is greater than the inward atmospheric pressure and the reason for a plane move upward is related to pressure difference between upper and lower part of the plane. Tell them that they will get the detailed answer in this chapter.

State the general objective of the unit as stated in the students‘ text book.

**Presentation**

## 3.1 Fluid Statics

It should be completed in approximately 5 teaching periods.

**Properties of solid, liquids and gases**

Pose the following brainstorming question:

Brainstorming question 3.2

Why gases are easy to compress, while liquids and solids are almost incompressible?

**Answer**: There are sufficient free space between atoms/ molecules of gases, thus allow compression under external pressure. However, molecules of solid and liquids are so close that external pressure cannot compress these molecules from their average lattice

site.

**Activity 3.1**: **checking compressibility of gases and liquids**

Dear teacher, support the students to conduct this experiment properly. Tell them to prepare the following materials in advance: Two identical syringes and water. Select where to conduct the experiment either in the laboratory or outside the class. Aware them the procedures and precautions listed in the experiment seriously.

**Result**

(i) A piston of air-filled syringe moves more than waterfilled syringe.

(ii) The appropriate result of this experiment indicates gases are more compressible than water due to larger distance between gas molecules.

In this subsection help students to learn:

- Distance between atoms of solids, liquids and gases
- Strength of forces between atoms of solids, liquids and gases
- Arrangement of atoms in the three states (whether fixed or move). Use figure 3.1 in students‘ text book to explain
- Now ask students:
    - why gases are easily compressed (use figure 3.2 of students‘ text book to explain this)
    - Why gases have no constant shape and volume, liquids have constant volume but not shape; solids have both constant volume and shape.
- Ask students the difference between fluid static and fluid dynamics
- Tell them what concepts categorized under fluid statistics and what are under fluid dynamics

**Discussion Question 3.1 (i): Answer**

**The** difference between solids, liquids and gases are summarized as follow

| Solid | liquid | gases |
|---|---|---|
| Atoms close each other and has fixed position | Atoms close each other but has no fixed position | Atoms far apart has no fixed position |
| Very Strong force between atoms | Strong forces between atoms | Very week forces between atoms |
| Not compressed thus have constant volume and shape | Not much compressed have constant volume but not constant shape | Easily compressed have no constant volume and constant shape |
| Do not flow, they are not fluids | Flow, they are fluids | Flow, they are fluids |

**Discussion Question 3.1 (ii): Answer**

Solids cannot flow, while fluids flow.

**Summary**

Use discussion question 3.1 (i) to summarize this section.

**Evaluation**

Explain the difference between solids liquids and gases.

**Pressure in Fluid**

**Introduction**

Start this subsection raising the subsection starting brainstorming question 3.3 in the students‘ text book and feedback them.

State the specific objectives of this subsection as it is stated in the students‘ text book.

Diagnose students‘ knowledge about pressure.

Define stress for them.

Tell them the difference between normal stress and tangential (shear) stress. Shear stress is due to resistance between moving particles.

Tell them also that shear stress is absent in fluids at rest and the only existing stress is normal stress.

Tell them that pressure is equally define in terms of normal stress as well as normal force per unit area.

Define pressure as:

–

where P is the pressure at the location of the contact area A.

Remind them pressure is a scalar quantity.

Ask them how pressure varies with area for a constant force and ask them to draw the pressure versus area and pressure versus force graph.

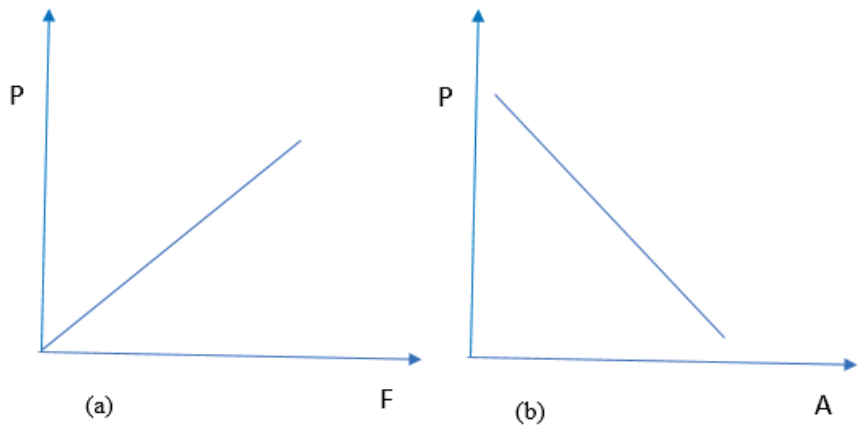



Figure 3.1 (a) pressure versus force for constant area (b) pressure versus area for constant force

Associate this relation to answer activity 3.2.

**Brainstorming question 3.3: Answer**

I. The difference in sink of the mattress is due to pressure difference as a result of difference in the area on which same force acted on. When we stand our weight acts on the area equal to the area of our feet when we sleep our weight acts on the area

equal to the area of our back side which is by far greater than the area of our foot. When the area increases the pressure decreases and vise versa.

II. Scissors, blade, saw and knives have sharp edges. Sharpening of the edge means decreasing the area on which the force to exert. Decrease in area for a given force increase the pressure as shown in Figure 3.1(b). The high pressure at the sharp edge of Scissors, blade, saw and knives makes them to cut objects easily.

III. The same reasoning for activity 3.2 also works for nails, syringes and pins to penetrate into objects easily.

Derive the unit of pressure from the relation of pressure with force and area. Show the equivalence of the SI units:

/

Tell other units of pressure such as millimeter mercury (mmHg), torr, atmosphere (atm), pounds per square meter (psi) with their relation shown as follow:

1 atm = 760 mmHg = 760 torr = 101.3 KPa = 14.7 psi

It is important that students realize all these units are simply different ways of measuring the same thing, namely the ratio of force to area (pressure).

Atmospheric pressure at sea level is 101.3KPa. Is this a large pressure or a smaller? To understand the magnitude of atmospheric pressure, you must relate it to something with which you are familiar. You can compare atmospheric pressure to the pressure you exert on the floor. Since pressure is defined as P = F/A, you can calculate the pressure you exert on the floor if you know your weight and surface area of contact. Measure the contact area of your feet. Draw the outline of your shoe on a piece of graph paper and count the number of squares inside the figure. Multiply the number of squares by the area of an individual squares to determine the approximate surface area of the bottom of your feet. Students answer may vary depending upon their weight and the surface area of the bottom of their feet. In general, students should find that air pressure is by far greater than the pressure they exert on the floor when standing on both feet. Associate this activity to solve example 3.1 in the students‘ text book.

Solve example 3.1, 3.2 and 3.3 cooperatively with your students.

**Summary**

- For fluid at rest, the shear stress is zero and the only existing stress is the normal stress and is called pressure.
- Generally, pressure is defined as a normal force exerted by a fluid (or a solid) per unit area.
- Unit of pressure is pascal, 1 Pascal = .
- The equation relates pressure in different system of units.
- Pressure is directly proportional to the applied force and inversely proportional to the area at which the force exerted.

**Evaluation**

- Ask them to define pressure, how it is related to applied force and area at which the force acted.
- Ask students to solve exercise 3.1 as a class work to assess them.

**Exercise 3.1: Answer**

**Solution**

The assumption that the two shoes have the same area tells us to increase the area twice for the same force (the weight of the woman).

(a) The total area of the shoes is obtained by the relation

The force exerted on the floor is the wait of the woman, which is obtained from the relation

/

Therefore, the pressure

/ ———

The result shows that when the area on which the force acts doubled the pressure is halved.

(b) To express the pressure in other pressure units we have to use relations in Eq 3.3.

To convert pressure in pascal to other unit, we use the relation

_____

where is the constant value of pressure in other system of units excluding pascal in Eq. 3.3, is the given value of pressure in pascal, is the value of pressure in the new system of unit. Here is . Therefore,

_____ _____ ;

_____ _____ ;

_____ _____ ;

_____ _____ ;

**Pressure in Gases**

**Introduction**

Start this lesson by posing brainstorming question 3.4.

***How a pressure of the gas formed?***

Start this subsection asking students the subsection brainstorming question 3.4. You can simply show students this resistance force of the inflated balloon. Make them to notice that the original shape of the balloon is maintained after the applied force (crushing) is removed. Ask them what is the cause of this restoring force.

**Brainstorming question 3.4: Answer**

**Answer**: The resistance of the crushing by the balloon is resulted from outward pressure due to the compressed air in the balloon.

**Presentation**

Link the following concepts:

- Collision of gas molecules with themselves and with the wall of the balloon due to their random motion
- Collision force, $\vec{}/$ , where $\vec{}$ is change of momentum, and is collision time. Use Figure 3.6 to make the process more visible for the students. Notify them that this force acts in all direction as the collision force is due to random motion of gas particles in the balloon. This is also the way how atmospheric pressure is acted.

Help students to understand the difference between absolute and gauge pressures. Use Figure 3. 7 of the students‘ text book to make clear the following relations:

Students should clearly understand the meaning of negative gauge pressure and vacuum pressure. Solve examples 3.4 and 3.5 with active participation of students in order to master the relation of these three pressures. Do not focus on the final numerical result only but also on explaining and relating concepts related to the examples. For example, in example 3.4, you can ask students the location of the chamber relative to sea level based on the value of atmospheric pressure. Tell them atmospheric pressure decreases with increasing altitude.

**Summary**

- The molecules of gases make a collision with the wall of the container constantly. This results in a constant collision force per unit area. This force per unit contact area gives the pressure of the gas. Air has a pressure whether or not a solid object i.e., the wall, is present.
- The actual pressure at a given position measured relative to absolute zero pressure or absolute vacuum is called the absolute pressure.
- . the difference between the absolute pressure and the local atmospheric pressure is called the gauge pressure.

Absolute, gauge, and vacuum pressures are related to each other by:

**Evaluation**

Tell students to solve exercise 3.2 as a class work to assess their understanding.

**Exercise 3.2: Answer**

Determine the absolute pressure where gauge pressure 61.152 KPa and atmospheric pressure is 14.0 Psi.

**Solution**

From activity, we have a relation,

$$\_\_\_\_\_$$

to convert pressure in pascal to other unit, where is the constant value of pressure in other system of units excluding pascal. Thus, to convert pressure from another unit to pascal we can use:

$$\_\_\_\_\_$$

$$\_\_\_\_\_$$

The absolute pressure is:

**Density**

**Introduction**

**Brainstorming question 3.5**

Why some objects float and others sink?

Start this lesson asking students the brainstorming questions above. Summarize students‘ reflection telling them floatation or sinking is related to the density of the object and the density of water.

Objects denser than water sink in water and others float. Tell them more quantitative and qualitative discussions of this topic will be treated in the next section, under Pascals principle.

**Presentation**

Define density as stated in the students‘ text book. Ask students how density vary with mass and volume observing the relation —. Ask students to compare density of gases, liquids and solids and relate it to atomic spacing as they have learnt from activity 3.1. They have to understand that at a given condition density of objects does not depend on the size of the object but only on the ratio of mass to volume, that is density is an intensive physical quantity. Make them to prove this by putting differently sized pieces of chalk in to a water and see whether they float or sink differently.

Students have to be informed that the density of most gases is proportional to pressure and inversely proportional to temperature. Liquids and solids, on the other hand, are essentially incompressible substances, and the variation of their density with pressure is usually negligible.

Solve example 3.6 and 3.7 together with the students. Ask them whether this person can sink or not in water by comparing its density with water. Ask them in which liquid is safe to swim: in denser liquid or less dense liquid?

Give exercise 3.3 as a class work.

**Exercise 3.3: Answer**

**Solution**

First, let we find the volume of the iron sphere from the relation:

— ——————

Therefore, the density is,

— ———— /

Remind them that the density of an object may help identify its composition. Then ask them whether this iron ball with density of / is pure iron or not by comparing the density of pure iron from Table 3.1 of their text book.

Students have to be notified that the density of gases is temperature and pressure dependent related by ideal gas equation of state, expressed as .

**Discussion Question 3.2: Answer**

The less dense liquid with density floats at the top and the most dense liquid with density will form the bottom layer. The middle layer is occupied by the intermediate density liquid.

**Summary**

- Density is the mass, m, per unit volume, v, of any object which is an important characteristic of substances.
- It affects pressure of fluids and determines whether an object sinks or floats in a fluid.
- The least dense liquid floats at the top; the least dense gas filled balloon accelerates upward and dense gas filled balloon accelerates downward.
- The ratio of the density of a substance to the density of some standard substance at a specified temperature is called relative density or specific gravity.
- Density of solids and liquids are not significantly affected by temperature; however, density of gas is highly affected by temperature. The equation that relates density and pressure of gases is the ideal-gas equation of state, expressed as .

**Evaluation**

- Define density and relative density.
- What is the density and the relative density (with respect to water) of a metal ball of radius 6 cm and mass 0.15 kg? (Answer: 13,300 kg )
- What is the product of the pressure and volume of a 2 mol of gas at 300 K? (Answer: 4988 N.m)

## 3.2 Properties of Pressure in Fluids.

It should be completed in approximately 6 teaching periods.

**Introduction**

Start this section posing the following idea:

Gas particles exert pressure in all directions due to their random motion. Do liquids exert pressure in all directions as that of gases? The simple answer for this question is yes, however the why question is answered when this lesson is completed.

**Presentation**

State the objective of this section as stated in the students‘ text book.

To check whether liquids exert pressure in all direction or not, perform Activity 3.3 with your students.

**Activity 3.3: Testing direction of pressure**

Dear teacher, support the students to conduct this experiment properly. Tell them to prepare the following materials in advance: A plastic bottle, five nails and water. Select where to conduct the experiment either in the laboratory or outside the class. Aware them the procedures and precautions listed in the experiment seriously.

**Results**

Identically-shaped parabolic streams of water shoot out of the holes. Evidently, the water inside must push out perpendicular to the wall of the bottle, just as gas pushes out perpendicular to the wall of a balloon. In addition, since the streams are identically shaped, the pressure at all points at the same depth in the fluid is the same.

**Pascal’s law**

Start this section asking students whether it is possible to change the pressure of gases in a container at a particular point without affecting other parts. To further clarify your question ask them: One of pressure increasing mechanism in gases, for example, is increasing the temperature of the gas from the relation, ——— , as shown from Eq. (3.6) of students‘ text book. Can it be possible to heat a particular region of a gas without affecting the other part within the same container? What is the implication of this?

Then feedback students properly and to answer your posing question, define pascal‘s principle as stated in the students‘ text book.

**Pascal’s law**: a change in the pressure applied to a fluid is transmitted undiminished to every point of the fluid and to the walls of the container.

You can also use Figure 3.12 a &b to further elaborate Pascal‘s principle.

Explain the microscopic explanation of pascal‘s principle in relation to transmission of compression and collisions of molecules from one region to another region.

List the application of pascal‘s principles like:

- Hydraulic lift (press)
- Hydraulic brake
- Hydraulic pumps

Explain the application of pascal‘s principle in a hydraulic brake.

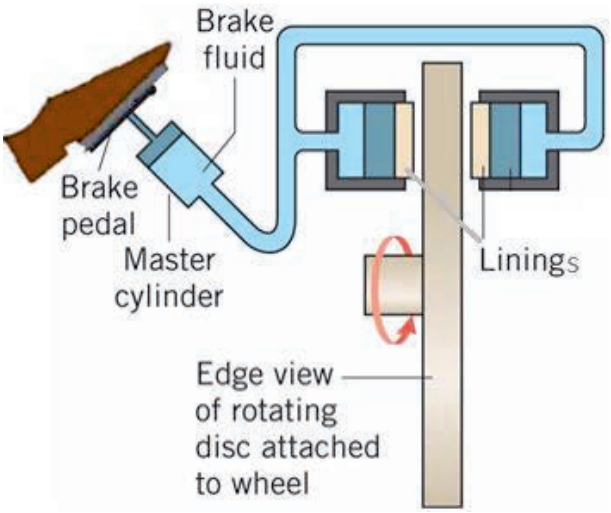



Figure 3.2: Working principle of hydraulic brake using pascal‘s principle

The pressure exerted at the pedal is transmitted through the brake fluid up to the lings. The linings sandwich the rotating disc attached to the wheel. Sandwiching the rotating wheel applies frictional force that decreases the rotational speed of the disc and the wheel. Then the vehicle stops.

**Summary**

- Fluids (gases and liquids) exert pressure in all directions
- An increase in the pressure of a static, enclosed fluid at one place in the fluid causes a uniform increase in pressure throughout the fluid (pascal‘s principle). The change in pressure at one point is transmitted to all part of the fluid due to continuous motion and collision of molecules of fluid.
- Pascal‘s principle is applied in Hydraulic lift (press),Hydraulic brake, and Hydraulic pumps

**Evaluation**

- Due gas and liquids respond similarly to the applied pressure at one point?
- State Pascal‘s principle
- List the applications of pascal‘s principle.
- Explain how a hydrauli brake works

**Hydraulic lift**

**Introduction**

Explain that hydraulic lift is an application of pascal‘s principle by relating to the previous lesson. Pose a question what is the purpose and working principle of a hydraulic lift?

## Presentation

Derive the relation between the applied forces at the two pistons by participating the students actively. Make them clearly understand that hydraulic lift is a force multiplier machine, i.e, a small force applied at the small piston raises a large weight at the larger piston from the relation:

(——) .

where and the area of large and small pistons; and are force applied a large and small piston. Since the ratio of the area of the large piston to a small piston (——) is

graeter than one; is greater than by (——) times. Solve example 3.8 in the class to help students understand how a small force can raise a large force, like cars, using a hydraulic lift.

Conduct activity 3.4 with your students.

**Activity 3.4: Pressure in a pair of connected syringes**

Dear teacher, support the students to conduct this experiment properly. Tell them to prepare the following materials in advance: Two syringes of different size, a piece of flexible plastic tube, two identical transparent beakers and bucket partly filled with water. Select where to conduct the experiment. Aware them the procedures and precautions listed in the experiment seriously.

***Results***

The system acts as a hydraulic press. The two syringes act as the pistons of the hydraulic press. More water is to be added on the beaker placed on the plumber of the large syringe as a small load on the small piston raises a larger load on the large piston.

Solve example 3.8 with your students.

**Summary**

- A hydraulic lift is an application of pascal‘s principle
- It is a force multiplier machine with factor of force multiplication equal to (——)

**Evaluation**

- Give exercise 3.4 as a class work

**Exercise 3.4: Answer**

**Solution**

The volume of liquid pushed down by the height, , is equal to the volume of liquid pushed 0.10 m at the larger piston

Therefore, to raise the car to 0.1 m, the small piston should push down 10 m.

**Variation of pressure with depth**

**Introduction**

Start this lesson by asking students the following question. Fluid exerts the same pressure in all direction at given point. Does this pressure the same at all depth?

**Presentation**

Help students to do experiment 3.5 as stated below to show effect of depth on the pressure of liquid.

**Experiment 3.5: Variation of pressure with depth**

Dear teacher, support the students to conduct this experiment properly. Tell them to prepare the following materials in advance: Three identical plastic bottles, three identical nails, a table and water. Select where to conduct the experiment either in the laboratory, inside or outside the class. If there is appropriate container to collect the water shots, it can also be conducted in the class. Aware students the procedures and precautions listed in the experiment seriously.

**Results**

The more the depth is the farther is the water shot travels away from the bottle. This implies the more is the pressure at the larger depth. Notify students that the water shot distance decreases with time as the depth of the water decreases with time implying the decrease in pressure with time.

Show students how to obtain the relation of pressure with depth of the fluid as:

That is, the pressure at a depth below a point in the liquid at which the pressure is is greater by an amount . It depends on the depth as well as the density of the liquid. If the liquid is open to the atmosphere and is the pressure at the surface of the liquid, then is atmospheric pressure.

Solve example 3.9 in the class to show dependence of pressure with depth of liquid.

Conduct activity 3.6 as follow to show shape and size of container does not influence the pressure if the depth is the same.

**Activity 3.6: Independence of liquid pressure with shape and size of container**

Dear teacher, support the students to conduct this simple experiment properly. Tell them to prepare the following materials in advance: Three plastic bottles of different diameter, three identical nails and a table. Select where to conduct the experiment. Aware students the procedures and precautions listed in the experiment seriously.

**Result**

This experiment shows the water shot distance is the same for all bottles. This implies that the size of the container does not affect the pressure of liquid at the same depth. It is also independent of shape of the container. You can use the container shown in the following figure if it is available in your school physics laboratory.

If a fluid can flow freely between parts of a container, it rises to the same height in each part. The pressure at the bottom of each column is the same; if it were not the same, the fluid would flow until the pressures became equal.

**Summary**

- The pressure of fluid depends on the depth of the fluid; it is independent of the shape and size of the container
- The pressure due to a depth of fluid is given by , where , and are density of liquid, gravitational acceleration and depth of liquid respectively.

**Evaluation**

- What is the pressure due to a 0.5 m depth of fresh water in an open container? What is the total pressure at the same depth? (Use density of water 1000 kg/$m^3$ and atmospheric pressure of 101.3 kP

**Atmospheric pressure**

**Introduction**

Start this lesson asking student Discussion question 3.3. Give them a hint as follow: One effect of a force is deformation. Therefore, the bottle should be deformed by unbalanced force from the exterior of the bottle. Ask them what is the source of this external unbalanced force. Why this unbalanced force has increased with decreasing altitude? Feedback them relating to the answer of discussion question 3.3 as follow:

***Discussion Question 3.3: Answer***

The sealed empty water bottle on an airplane collapses as the plane descends from a higher elevation to a lower elevation. This is because even in a pressurized cabin, air pressure at the lower elevation is slightly greater than at higher elevation, and the increased pressure crushes the bottle as shown in Figure 3.16 in the students‘ text.

**Presentation**

Discuss the following:

- How air pressure on the surface of the Earth is created and how it is varied with altitude? Relate this with the pressure due to depth of fluid.
- How depth and density affect air pressure at different altitude?

- At what altitudes are the maximum and the minimum atmospheric pressures are observed on the surface of the Earth?
- What are the consequences of decline in atmospheric pressure with altitude?

Discuss Discussion Question 3.3 & 3.4 and conduct and discuss practical activities 3.7 and 3.8 with your students. Feedback them based on the students‘ response and the brief answers given below.

***Activity 3.7: Effect of temperature on Pressure***

Dear teacher, support the students to conduct this experiment properly. Tell them to prepare the following materials in advance: Two identical shape and size plastic water bottle and hot water. Select where to conduct the experiment. Aware students the procedures and precautions listed in the experiment seriously.

***Result***

When a tightly covered plastic bottle filled with a hot water left until water cool down to room temperature, the plastic bottle will collapse. The reason is that when the hot water was sealed the external pressure and internal pressure are balanced. As the temperature decreases, the internal pressure decreases since the inside of the bottle is out of the influence of atmospheric pressure. Due to this pressure difference, more force is acted inward and collapses the bottle. However, if the bottle is open the decrease in the pressure due to decrease in temperature is compensated by atmospheric pressure. No net fore is acted on the wall of the bottle. Thus, nothing happened to the bottle.

**Activity 3.8: Effect of atmospheric pressure on the flow of confined water**

Dear teacher, support the students to conduct this experiment properly. Tell them to prepare the following materials in advance: One plastic water bottle, nail and water. Select where to conduct the experiment. Aware students the procedures and precautions listed in the experiment seriously.

**Result**

(i) All the water will not leave the water bottle. Because, when a tightly covered plastic bottle filled with water is poked at the bottom, water comes out through this poke only if the pressure due to depth of the water, , is greater than the atmospheric pressure acting through the poke. If the atmospheric pressure is greater than , no water comes out of the poke; rather air enters into the bottle until the internal and the external pressures are balanced.

(ii) When the lid is open, all the water comes out through the poke as the atmospheric pressure acting downward at the top and upward at the bottom through the poke cancels each other. The gravitational force on the water is unbalanced and all the water flows out through the poke at the bottom as a result of this unbalanced gravitational force.

**Discussion Question 3.4**

**Answer**

(i) Nose bleeding is a common experience at high altitudes since the difference between the blood pressure and the atmospheric pressure is larger in this case. The blood pressure is by far higher than the atmospheric pressure and the delicate walls of veins in the nose are often unable to withstand this extra stress.

(ii) As the altitude increases the density of air decrease. The air at higher altitudes is colder, less dense, and contains fewer oxygen molecules. This means that you need to take more breaths in order to get the same amount of oxygen as you would at lower altitudes. The higher the elevation, the more difficult breathing becomes. Therefore, playing football and other sport games are difficult at higher altitude.

**Summary**

Summarize your lesson as follow:

Atmospheric pressure is created by column of air above a particular point. It decreases with increasing altitude.

The maximum atmospheric pressure on the surface of the earth is measured at sea level.

Cooking, working of car engine and breathing is difficult at high altitude due to the lack of sufficient air. Nose bleeding is common in high altitude than low altitude.

**Evaluation**

Why empty plastic bottles tightly closed at high altitude collapse when they descend to lower altitude?

Explain how the atmospheric pressure varies with altitude.

Why a tightly closed plastic bottle filled with hot water collapses when it cools down?

How can water stay inside a closed bottle with a hole at the bottom?

**Measuring pressure**

**Introduction**

Ask student to list as many pressure measuring devices possible. Ask also what is the principle behind pressure measuring device. Feedback properly to their responses. Tell them, pressure measuring device use the principle of pressure due to depth of a liquid, the detail is to be discussed in this lesson.

**Presentation**

Ask students to read the concepts written under this section about Barometer and manometer and report what principles do each pressure measuring device use. Ask them to list the similarities and differences between barometer and manometers.

**The Barometer**

The atmospheric pressure due to height, h, of a mercury in a barometer tube is given by

where is the density of mercury, is the local gravitational acceleration, and h is the height of the mercury column above the free surface.

Students should understand that shape, size and heigh of the tube does not affect the height of the mercury in the barometric tube as shown in Figure 3.18 of students‘ text book.

Solve Example 3.10 in the class together with the students to strengthen their understanding.

**The Manometer**

Remove any confusion why we use three equations

}

to measure the pressure of gases using the following figure (Figure 3.19 in the students‘ text book), where denotes density of the liquid, denotes gravitational constant, is the height of the liquid column.

Solve Example 3.11 applying the appropriate formula shown above.

**Summary**

Summarize your lesson as follow:

- Atmospheric pressure is measured by a device called a barometer
- The principle is pressure due to depth of a liquid (mercury) and given by: .
  The length and the cross-sectional area of the tube have no effect on the height of the fluid column of a barometer.
- A manometer is a u-shaped that can be used to measure the pressure of a gas trapped in a container. If the end opposite to the gas trapped is closed it is said to be closed end manometer otherwise it is called closed end manometer. The principle similar to that of barometer.

**Evaluation**

- **Give Exercise 3.5 and 3.6 as class work**

**Exercise 3.5: Answer**

**Solution**

(i). The meaning of the 700-mmHg barometric reading is that the atmospheric pressure at this region can push up mercury in the barometric column 700 mm above the level of mercury in the container. To solve the pressure in pascal, we use density of mercury, .

The pressure due to this column of mercury is obtained from the relation:

— /

(ii). We can use the values 1atm= 101.3 KPa, and from the relation , we have

— ——————————
/ /

There is not really a manageable length. The reason why it is commonly used mercury is due its high density, so that it reduces the barometric reading to a manageable length of the tube.

**Exercise 3.6: Answer**

**Solution**

Since the manometer is isolated from the atmosphere, the column of liquid at t the right arm 26.4 cm above liquid level at the left is equivalent to the pressure of the gas, hence given by:

Using the density of mercury, we obtain:

/

## 3.3 Archimedes Principle

It should be completed in approximately 3 teaching periods.

**Introduction**

Start this subsection asking students the subsection brainstorming question 3.6. Feedback students' response about the difficulty of submerging objects in to a liquid in relation to density of the objects.

State the specific objectives of the section as stated in the students‘ text book.

**Brainstorming question 3.6: Answer**

All fluids act up thrust (buoyant) forces against gravity which is proportional to the volume of displaced fluid. If we add an object into liquid, the liquid acted upthrust force on the object. If the density of the liquid is greater than that of the object, more upward force is acted on the object than the gravitational force on the object. Therefore, the object accelerates upward.

**Buoyance force**

**Presentation**

Define buoyant force state Archimedes principle. Support your definition by examples like: though boats and ships are made of metals of density greater than water, they still can float carrying large number of people and goods. The reason is that every liquid has upward force on objects inside it due to the pressure difference between the bottom and top of the object. More pressure is acted at the bottom due to more depth of the liquid at the bottom. This unbalanced pressure results in upthrust force.

Students has to understand the equivalence of the buoyant force and the weight of the displaced liquid by the object as:

Show how this leads to

(3.12)

where is the volume of the fluid displaced by the object?

Solve example 3.13 with students to make buoyant force and Archimedes principle. Remind student how dense metals are used to construct boats and ships without sink on the less dense water compared to the metals‘ density. That is, by shaping the metal to have more volume, it can be possible to float on water carrying large weight.

**Activity 3.9: Buoyancy**

Dear teacher, support the students to conduct this experiment properly. Tell them to prepare the following materials in advance: two glass cups, table salt, spoon, two eggs and water. Select where to conduct the experiment. Aware students the procedures and precautions listed in the experiment seriously.

**Result**

The egg immersed in a salt solution floats. The reason is the salt solution is denser than the water. Hence the displaced salt solution has more buoyant force than the pure water.

**Summary**

Summarize the buoyance force section as follow:

- The upward force exerted by a fluid on any immersed object is called a buoyant force.
- Buoyant force is based on the fact that pressure increases with depth in a fluid, this results in greater upward force at the bottom of an object than the downward force on the top of the object in a fluid.
- the buoyant force and the weight of the displaced liquid by the object are equal, i.e.;

**Evaluation**

- Ask students to define buoyance force.
- Ask factors affecting buoyance force
- Give exercise 3.7 as a class work

**Exercise 3.7: Answer**

**Solution**

The Weight in vacuum is 686 N, the density of a person is / and the density of air is / .

The buoyant force due to air is

where , the volume of displaced air which is equal to the volume of a person given by:

, thus the buoyant force is

/ /

The scale reading when a person is submerged completely in the air is

. The percentage of the weight loss due to the buoyant for is . Since the weight lost due to the buoyant force of the air is only 0.133%, the buoyant force can be ignored.

**Totally Submerged Object and floating objects**

**Presentation**

Ask students to compare mass of the object and the mass of displaced liquid having equal volume if:

(i) density of object is greater than the liquid,
(ii) density of object is less than the liquid and
(iii) density of object is object is equal to density of liquid

Now ask them to compare the weight of the object and the upthrust force in the above three situations. Make them to decide on which situations objects:

(i) total submerge and stay at the bottom of the liquid
(ii) Part of it submerged and floats
(iii) Totally submerged but can be anywhere inside the liquid rather than staying at the bottom of the liquid

Show them how to obtain the volume fraction of the floating object inside the liquid using the densities of object and the liquid as:

This equation shows that the fraction of the volume of a floating object that is below the fluid surface is equal to the ratio of the density of the object to that of the fluid.

Solve examples 3.12 and 3.14 in the class to help student master the concept of buoyancy, submerging and floatation. Please do not miss important qualitative description of the problems to real situations. For example, in example 3.12 remind students how submerged part of an iceberg is dangerous for ships. In example 3.14, remind students that Archimedes principle can be used to verify the purity of objects as density is peculiar characteristics of materials.

**Summary**

Summarize the Total Submerging and floatation lesson as follow:

- If the density of the object is greater than the density of the fluid, the upward buoyant force is less than the downward gravitational force and the unsupported object sinks.
- If the density of the object is less than the density of the fluid, the downward gravitational force is less than the weight of the liquid displaced by the whole volume of the object (buoyant force) and the unsupported object floats with some fraction of the object outside the liquid to balance the gravitational force and the buoyant force. The ratio of the volume of displaced fluid to the volume of a floating object is equal to the ratio of the density of the object to the density of the fluid as:

$$\frac{\text{volume of displaced fluid}}{\text{volume of floating object}} = \frac{\text{density of object}}{\text{density of fluid}}$$

- If the density of the submerged object equals the density of the fluid, the net force on the object is zero and the object remains in equilibrium. It can be anywhere inside the fluid.

**Evaluation**

- Ask student in what situation objects submerged totally, and floats
- Give exercise 3.8 a class work and exercise 3.9 a home work

**Exercise 3.8: Answer**

***Solution***

We have to find the density of the crown and compare it to the density of gold. The mass of the crown is — ——— / .

The buoyant force on the crown is . It is related to the weight of displaced water by:

This leads to,

——— ——————— / /

For totally submerged object the volume of the object and the volume of displaced liquid is the same. Therefore, the volume of the crown is . The density of the crown is then,

——— ——————— /

The density, of the crown is by far less than that of the gold, therefore, the crown is not made of gold. The crown density is closer to the density of silver (10,500 / ) than other ornamental metals.

**Exercise 3.9: Answer**

**Solution**

To find the density of the wooden block we can use the relation —— —— (Eq. 3.16 in the students' text). The block density is obtained as:

—— / /

Dear teacher, facilitate the following experiments to concretize Archimedes principle, if possible, in the physics lab.

**Activity 3.10: Measuring buoyant force and density of liquid**

Dear teacher, support the students to conduct this experiment properly. Tell them to prepare the following materials in advance: two 100 ml beakers, a pendulum bob, spring balance and water. Select where to conduct the experiment.

**Result**

If students follow the procedure properly and make appropriate measurement, the decrease in the weight of the pendulum bob in the water and the weight of the displaced water are the same. This value is called buoyant force, . Thus, their experiment has to verify Archimedes principle. Once the buoyant force is obtained, the density of the water is obtained from the relation:

## 3.4 Fluid Flow

It should be completed in approximately 2 teaching periods.

**Introduction**

Start this section from the brainstorming questions:

(i) What mechanism maintains the blood flows through our circulatory system?

(ii) How can a plane fly against gravity?

Feedback students‘ response suitably.

**Brainstorming question 3.7: Answer**

Tell them both brainstorming questions are related to pressure difference. The blood flows due to pressure difference in the circulatory system. The high pressure at the left ventricle of the heart drives the blood to flow through the body. Note that the speed of flow in the capillaries is considerably reduced relative to the speed in the aorta due to the significant increase in the total cross-sectional area at the capillaries. This low speed is to allow sufficient time for effective exchange to occur although it is equally important for the flow not to become stationary in order to avoid the possibility of clotting.

Air moving over the curved upper surface of the airplane wing will travel faster and thus produce less pressure than the slower air moving across the flatter underside of the wing. This difference in pressure creates lift which is a force of flight that is caused by the imbalance of high and low pressures.

Then state the specific objective of this section as stated in the students‘ text.

**Presentation**

Ask students the difference between turbulent and laminar (steady) flow.

Tell students the condition for these types of flows.

Make them know the meaning of viscosity and streamline.

Define flow rate ( ) as – ¯ , where V is volume of flowing fluid, t is flow time, A correctional area and ¯ is average flow speed. Apply this relation to solve example 3.15 in the class participating students. Let students to imagine how much blood volume means. It is liters and can completely fill a tank of 58.5 m x 58.5 m x58.5 m.

Using this figure in the students‘ text, show the *equation of continuity* for incompressible fluid flow at different diameter pipe as:

}

where is the average speed of the fluid passing cross section and is the average speed of the fluid passing cross section .

Solve example 3.16 participating students.

Discuss discussion Question 3.5 in the class.

Discussion Question **3.5: Answer**

There is less pressure on the top surface where the air is moving compared to the pressure from the stationary air below the paper. The greater pressure from below will cause the paper to rise as show in figure 3.3 (b).

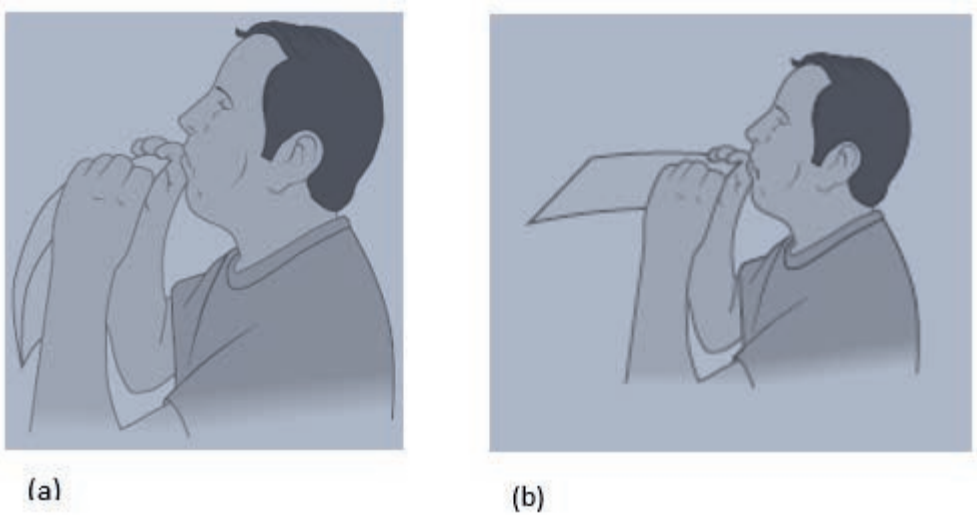



Figure 3.3 A piece of paper held at the corner (a) before air is blown across the top (b) after air is blown across the top

Airplane also flies against gravity by lowering the pressure of upper part of the plane to get unbalanced upward force. This can be attained by moving the air at the upper part of the plane to move fast.

Discus how fluid dynamic (flow) explains the phenomena Like:

- the flow of blood through blood vessels.
- a snoring sound
- wind musical instruments.

**Summary**

Summarize the fluid flow section as follow:

- When the pressure in one region of the fluid is lower than in another region, the fluid tends to flow from the higher pressure region toward the lower pressure region.
- The flow is said to be steady, or laminar, if each particle of the fluid follows a smooth path without crossing. Such flow always occurs when the fluid flow with low velocity and in small diameter pipes.
- Above a certain critical speed, fluid flow becomes turbulent. The adjacent layers of the fluid cross each other and move randomly in a zigzag manner.

- As a solid surface is acted by a frictional force when it slides over another solid, there is also an internal frictional force in liquid, called viscosity, when two adjacent layers of fluid try to move relative to each other.
- The path taken by a fluid particle under steady flow is called a streamline.
- Flow rate ( ) is defined as – ¯, where V is volume of flowing fluid, t is flow time, A correctional area and ¯ is average flow speed.
- the *equation of continuity* for incompressible fluid flow at different diameter pipe as:

  • }

where is the average speed of the fluid passing cross section and is the average speed of the fluid passing cross section .

- Fluid dynamic (flow) well explains the phenomena Like: the flow of blood through blood vessels, a snoring sound and wind musical instruments.

**Evaluation**

- How flow velocity affects the fluid pressure?
- List fluid properties explained in stationary and flowing fluid.
- Give Discussion Question 3.6 as class work.

  Discussion Question **3.6: Answer**

  The consequences of the equation of continuity can be observed when water flows from a hose into a narrow spray nozzle: it emerges with a large speed—that is the purpose of the nozzle. Conversely, when a river empties into one end of a reservoir, the water slows considerably, perhaps picking up speed again when it leaves the other end of the reservoir. In other words, speed increases when cross-sectional area decreases, and speed decreases when cross-sectional area increases.

Discussion Question 3.7: Answer

## 3.5 Safety and High Pressure

It should be completed in approximately 3 teaching periods.

**Introduction**

Dear teacher, start this section from the following brainstorming question.

**Brainstorming question**

Dear students, have you ever seen while metal and wood technicians spraying ink or varnish on wooden or metallic furniture? How do these spraying machines work? Have you observed other equipment having similar purpose?

Feedback appropriately for the students‘ response. The listed machine in the brainstorming question works by high pressure. Highly compressed air ejects the ink or the varnish at high pressure. Ask them to list other machines working in similar principles, like pressure cookers, liquid petroleum gas cylinder, pressure washer.

**Presentation**

Tell them how much high pressure is important in different technologies like:

- Pressure cooker
- liquid petroleum gas cylinder.
- studying physical properties of various bodies (mainly solids) and to transform their nature
- filling vehicles tires
- to control the microorganism activity called pascalization. Pascalization can be used to increase the shelf lives of perishable foodstuffs: juice, fish, meat, dairy products, etc.
- High pressure important in many scientific and technological fields, like biology, chemistry, environmental engineering, food technology, material science, pharmacy, and physics.
- List the high-pressure equipment components for students: high-pressure compressors, high pressure piping, high pressure vessels, Safety Accessories and high-pressure instrumentation.

Arrange students in to five groups to read the five listed components of pressure system and reflect what they have understand. Feedback the reflection properly.

**Summary**

Summarize the lesson as follow:

- High pressure device work at a pressure far greater than 1 atmosphere.
- High pressure system has diverse applications like High pressure cookers, petroleum gas cylinders, laboratory gas cylinders, tyre inflators, high pressure washers, food pascalization
- High pressure affects many scientific and technological fields, like biology, chemistry, environmental engineering, food technology, material science, pharmacy, and physics.
- High pressure equipment are combination of different components like high-pressure compressors (or pumps), high pressure piping, high pressure vessels, Safety Accessories and high-pressure instrumentation

**Evaluation**

- What is common property of all high-pressure devices
- List some of the high-pressure equipment (see answer from Discussion Question 3.9(i))
- What are the major components of high-pressure equipment and what are their function?

**Safety for high pressure equipment: High Pressure Gas Cylinders, High Pressure washers**

## Introduction

Aware students that high pressure devices have serious hazards if they have not been properly managed. List for them the main hazards from high pressure devices like impact from the blast of an explosion, impact from parts of equipment that fail or any flying debris, impact with the released liquid or gas (such as steam), fire resulting from the escape of flammable liquids or gases.

**Presentation**

Mention the Common causes of pressure system and equipment risks like:

- Damaged equipment or system design

- Poor or no maintenance
- An unsafe system of work
- Operator error due to lack of training/supervision
- Incorrect installation
- Inadequate repairs or modifications

Ask student to suggest the possible measure to avoid the listed causes of high-pressure equipment risks? Classify the class into two groups and read and discuss the safety rules for high pressure gas cylinders and high-pressure washer. Make them present what they have understand from their reading and discussion. Feedback them properly.

**Summary**

To keep oneself and his family, int is important to:

- Understand main hazards from high pressure devices
- To aware common causes of high-pressure risks
- Follow properly the safety rules for high pressure devices

**Evaluation**

- List at least three main hazards from high pressure devices
- List at least four common causes of high-pressure risks
- List at least four safety measures for high pressure gas cylinder
- List at least three safety measure to be taken for high pressure washers.

**Discussion Question 3.7: Answer**

(i). Some applications of high-pressure device include:

- Pressure cooker
- liquid petroleum gas cylinder.
- studying physical properties of various bodies (mainly solids) and to transform their nature
- inflating vehicles tires

- pascalization to increase the shelf lives of perishable foodstuffs: juice, fish, meat, dairy products, etc.
- High pressure important in many scientific and technological fields, like biology, chemistry, environmental engineering, food technology, material science, pharmacy, and physics.

**(ii) .** Common causes of high-pressure system and equipment risks include:

- Faulty equipment or system design
- Poor maintenance
- An unsafe system of work
- Operator error (through lack of training/supervision)
- Incorrect installation
- Inadequate repairs or modifications

(iii). See the safety measures of high-pressure cylinder and high-pressure washer under their respective section.

## Answer for the unit end questions

Teachers should take two periods to solve selected the unit end questions.

1. Answer

   Ans: The reason is that the size of atoms is in the order of nanometer.

2. Answer

   The density of an irregular shaped object can be determined as follow:

   - measure the mass of the object in air
   - Fill water in a graduated container
   - Put the object in to water filled container and collect the overflowed water
   - Measure the volume of the overflowed water. The volume of the overflowed water is the same as the volume of irregular object.
   - Then divide the mass of the irregular object measured in air to the volume of the irregular object to get the density of the object.

3. **Answer**

The pressure difference with height is due to the weight of liquid above that point. However, if a pressure is increased at a point this pressure is equally distributed undiminished to all part of the fluid, i.e., it is independent of depth.

4. **Answer**

In preparing a barometer, a glass tube at least 760 mm long and closed at one end is filled with mercury and then carefully inverted into a pool of mercury. The level of the mercury in the column will fall slightly and then become steady. The height of the column of mercury measures the pressure of the atmosphere. The reason is that the surface of the mercury pool at the base of the column is pressed by column of atmospheric air. On the surface under the mercury column, the mercury is pressing down. The two pressures must be equal. If they were not, mercury would be flowing into or out of the column, and the height of the column would not be steady. The atmosphere must be exerting a pressure equal to that exerted by the mercury column. In other words, the atmospheric pressure can carry a volume of mercury in a barometer tube 760 mm above the level of mercury in the mercury pool.

5. **Answer**

The pressure at the bottom of the object is greater than the pressure at the top of the object. This pressure difference creates upthrust force on the object called buoyant force. This means the upward force from water has to be greater than the downward force from water.

6. Answer

The Archimedes principle says that a floating body will displace an amount of fluid that is equal to its weight. Since the iceberg floats, it weighs the same as the water it displaces. If icebergs had the same salt concentration as the ocean, it would occupy exactly the same volume as it displaced and the sea level wouldn't change.

7. Answer

**Option one**: To measure the density of a liquid you do the same thing you would for a solid. Mass the fluid, find its volume, and divide mass by volume. To measure mass of the fluid, weigh it in a

container, pour it out, weigh the empty container, and subtract the mass of the empty container from the full container.

Option two:

Measure the mass of an object with known density in air and in the liquid whose density is unknown. Find the buoyant force. The buoyant force is equal to the weight of displaced liquid which is the product of the volume and density of displaced liquid with gravity.

8. Answer

Since the volume of the displaced oil is the same in both cases the buoyant force is the same on both objects.

9. Answer

Givens: , ,

– –

Solution

— ——————— /

10. **Answer**

The graph shows exact value of volume and mass at ( . Therefore, the density is given by

— ——————— /

Doubling of the mass of the material also doubles the volume of the materials. Therefore, no change is observed on the density of the material.

Comparing the result with density of different substants from Table 3.1 in the students‘ text, the material could be copper.

11. **Answer**

;

;

;

12. Answer

Take the density of blood is nearly equal to water density (1000 kg/ ).

The weight of the column of water should be equal to the blood pressure.

13. Answer

Take density of ice 917 and that of water 1000 .

Solution, since the ice floats its weight is the same as the buoyant force.

,

Therefore, the fraction of ice submerged inside the water is 0.917.

14. Answer

(a) mass of the displaced water is equal to mass loss in water.

(b) since the rock is totally submerged the volume of the displaced water is equal to the volume of the rock, which obtained as:

(c)

15. Answer

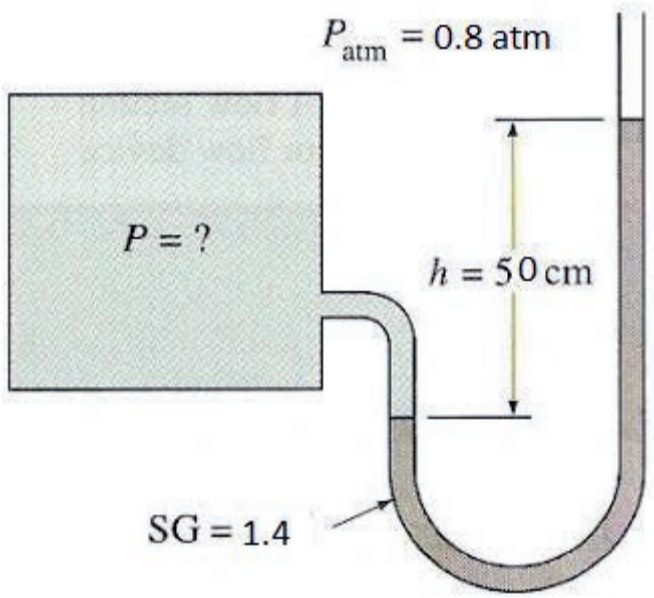
Assumption: the density of the gas in the tank is much lower than the density of the manometer fluid.

The specific gravity of the manometer fluid is given to be 1.40. We take the standard density of water to be 1000 kg/ .

The density of the fluid is obtained by multiplying its specific gravity by the density of water.

Thus, the absolute pressure is:

(a)

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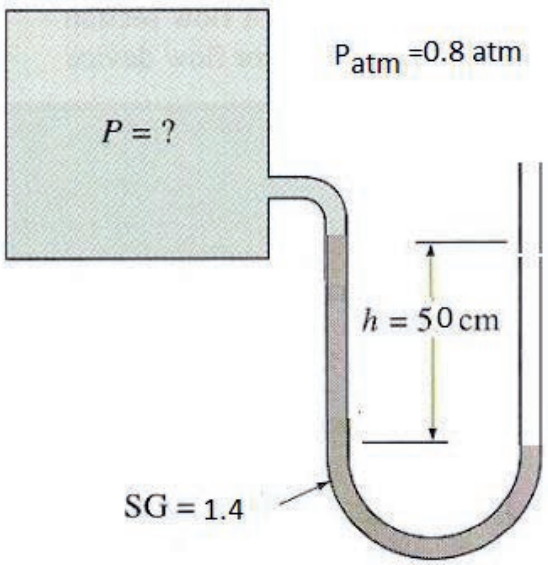
(b) — / ———




16. Answer

Gauge pressure due to depth of liquid is obtained as:

,

this implies,

At the depth of 9 m, the gauge pressure is

17. Answer

Assumptions: (1) The weight of the woman is distributed uniformly on the imprint area of the shoes. (2) one foot carries the entire weight of the woman during walking, (3) the weight of the shoe is negligible.

Solution

The minimum area of the shoe required to walk without sinking is obtained from the relation:

Notice that this is a very large area for a shoe, and such shoes would be impractical to use. Therefore, some sinking of the snow should be allowed to have shoes of reasonable size.

18. Answer

(a) From Archimedes Principle, fractional volume inside water when the lung is empty:

the volume of the man without the air in the lung is:

fractional volume inside water when the lung is I full:

the volume of the man with the air in the lung is:

Therefore, the volume of air inhaled is

(b) The obtained volume is 1.6 L which is reasonable volume of the lung.

19. Answer

The relation of force /mas on the larger and small piston of the hydraulic press is given by:

20. Answer

The mass of the fluid is

The density of the fluid is

21. Answer

(a) Assumptions, the density of blood is equal to the density of water, 1000 kg/

Givens: radius large artery and smaller artery , ,

From equation of continuity

(a)

22. Answer

Givens: , , , and

.

(a) The scale reading in the air is the difference of the actual weight and the buoyant force due to air.

(b) In a swimming pool, the scale reading is:

Since the density of the man is less than the density of water, the man is weightless in the water, i.e., it is floating.

23. Answer

(a) Givens: , radius of aorta ,

(b) Givens: , ,

The rate of flow in capillaries is

# Unit 4: Electromagnetism

This unit requires approximately 14 periods of teaching time.

**Introduction**

Electromagnetism is a fundamental force in nature consisting of the elements electricity and magnetism. The interaction of electrically charged particles and uncharged magnetic force fields with electrical conductors creates the electromagnetic fields. Devices that produce an electromagnetic field when electricity is applied are called electromagnets. changing magnetic field creates an electric field. Years later, theoretical work by Maxwell showed that the reverse is also true: a changing electric field creates a magnetic field.

Dear teacher, can you brainstorm and introduce electromagnetism by showing how it is applied in their daily life by connecting electricity and magnetism so that they can reflect the application of electromagnetism on devices such as radios, televisions, computers, tape recorders, VCRs, CD players, lasers , electric motors and generators.

## 4.1. Magnets and magnetic fields

This section requires approximately 1 periods.

Dear teacher, before presenting your lesson , you can Brainstorm your students by asking:

- what is magnet, what are the properties of a magnet ?
- Ask them how magnetic field is created.
- In-courage them to explain what are the sources of magnetism?
- State the objectives of this lesson
- And what is the difference between electric field and magnetic fields?

**Answer to Brainstorming question 4.1:**

a) On Earth, flowing of liquid metal in the outer core of the planet generates electric currents. The rotation of Earth on its axis causes these electric currents to form a magnetic field which extends around the planet

b) The answer is no,: Each half of the bar magnet has a north pole and a south pole. You can even continue cutting each piece of the bar magnet in half, and you will always obtain a new, smaller magnet with two opposite poles.

**Presentation**

- Students have been introduced with their previous knowledge on magnets (what is magnet, properties of magnets , how magnets are created and relate with Earth's magnet , identify geographic and magnetic poles of the earth.
- Motivate your student to clearly distinct and reflect their understandings on electric and magnetic fields
- Discuss with your students how magnets are arranged them selves with the earth‘s magnetic pole in relation to the geographic poles of the earth.
- Discuss why magnetic monopoles are not existed like electric monopoles, and you can ask them what will happen the poles of the magnet when it is continuously cut in to pieces.
- Motivate students to make small group and discuss on configuration of magnetic field patterns by drawing when:
  - There is single magnet
  - Two magnets placed N-S to each other and
  - Two magnets placed N-N or S-S as shown in Fig.4.1 of students text.
- This can help you to understand the misconception or misunderstanding among students, how magnetic fields are configured for different arrangement of magnetic poles and it can also help you understanding how they can differentiate it with electric fields.
- Invite students to explain about electromagnet, make differentiation between bar magnet.
- It is also possible to explore the availability of electromagnet or another magnet in our daily activities.
- Explain how the polarity of magnets can be identified by compass, more over you can also explain the compass needle is arranged with the Earth;‘s magnet.

**Summary**

You can summarize this section by explaining:

- Nature of magnets; like permanent magnet, electromagnet
- The repulsive and attractive nature of magnets
- Magnetic Field is the region around a magnet where other magnetic material will experience a force.

**Assessment**

Dear teacher give home work and class work by selecting questions from exercise 4.1 and end unit problems. Provide feedback for on each questions.

Ask students the following conceptual questions:

- difference between permanent magnet and electromagnet. .
- origin of earth magnetism.
- difference between electric field and magnetic field.

**Exercise 4.1 Answer**

1) C. Like poles attract each other

2) True (Electromagnet generate magnetic field due to electric current.)

3) The region around a magnet where magnetic force is detected.

4) Some differences are listed in the student text book.

5) Permanent magnets are materials where the magnetic field is generated by the internal structure of the material itself. The electromagnet generates a magnetic field when an electric current is provided to it and it loses its magnetism when the current is off.

## 4.2 Magnetic Field Lines

This section requires approximately 1 periods

- ✓ Dear teacher you can start your lesson by asking some brainstorming questions like:
  - The source of magnetic field lines
  - Draw magnetic field lines of a bar magnet
  - Difference between electric and magnetic field lines.

State objectives of the lesson.

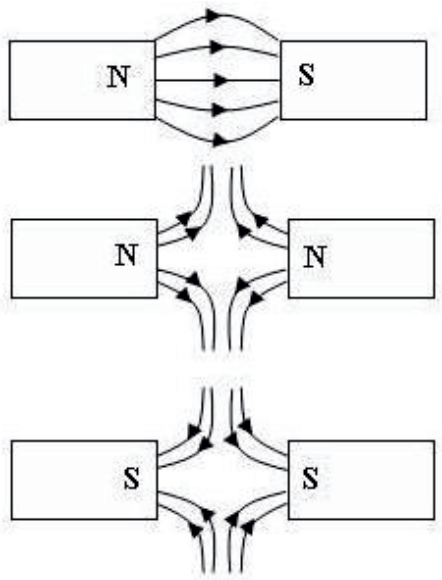
**Answer to brainstorming question 4.2:**

While electric field lines begin with positive charges and end with negative charges, magnetic field lines are closed rings, extending from the south pole to the north pole and vice versa (or, equivalently, from the north pole to the south pole and vice versa) . If magnetic mono poles existed, the magnetic field lines would begin and end on them.

**Presentation**

Ask your students how magnetic field lines are configured for different orientation of magnetic poles which is summarized in the figure below.

- Explain to students where the field lines will be strong.
- Ask students to identify the direction of the field lines outside the magnets
- Explain to them that the stronger magnetic field can exist near the poles of the magnet.
- Explain to them that the magnetic field lines form closed loop by leaving the north pole and entering the south pole of the magnet and ask them if it is true for electric field lines which can help you to trace if there is misunderstanding between the two.



**Assessment**

You can evaluate your students by asking objective related question to see whether they grasp something. Sample evaluative question are as given below:

- Draw the magnetic field lines for bar magnet.
- In which part of the magnet is the magnetic field strong?
- What are the properties of magnetic field lines?
- Select questions from exercise 4.2 and end unit problems and give as home work and class work. Provide feedback for each question.

**Exercise 4.2 Answer**

1) Magnetic field lines are imaginary lines used to represent magnetic fields. They describe the direction of the magnetic force.

2) True

3) Some properties are mentioned in student text book.

4) D. All are true

## 4.3. Current and magnetism

This section requires approximately 3 periods

- Introduce your lesson by recalling the previous lesson on magnetic field and magnetic field lines.
- Brainstorm your students by asking what electromagnet is how it can be constructed.
- Introduce the specific objective of your lesson

**Answer to brainstorming question 4.3**

Electricity and magnetism are essentially two aspects of the same thing, because a changing electric field creates a magnetic field and a changing magnetic field creates an electric field. (This

is why physicists usually refer to electromagnetism or electromagnetic forces together, rather than separately.)

**Presentation**

- State the Amper‘s law to students in relation to the the magnetic field.
- State the magnetic field for a long straight wire and write the mathematical relations between the magnetic field and the current through the wire ( ⃗ —)
- Moving current in a conductor produces magnetic filed
- Electric acts on charges both at rest or in motion where as magnetic force only acts on moving charge.

**Assessment**

You can evaluate the understanding of your students on the lesson by asking objective related question like:

- State Amper‘s law
- relation between current and magnetism.
- Factoring increasing the strength of the magnetic field around current carrying conductor.
- Select questions from exercise 5.3 and end unit problems and give as home work and class work. Provide feedback for each question.

**Activity 4.1**

Dear teacher this activity helps the students to understand electromagnet. Assists the students in performing the activity. When the battery is connected electric current flows through the coil therefore, the nail is magnetized. The nail attracts the paper clips. When the current is off the nail loses its magnetism thus, the paper clips are not attracted by the nail. The nail behaves like a magnet when current flows through the coil.

**Exercise 4.3 Answer**

1) The magnetic field B is inversely proportional to the distance r.

$B_1$ = 0.8 T, $r_1$=0.5cm

$B_2$=?, $r_2$=1cm

Since r is doubled, the field decreases by half. Therefore, $B_2$=0.4T

2) C. The type of the wire.

3) False (The magnetic field B is inversely proportional to the distance r.)

## 4.4. Electromagnetic Induction

This section requires approximately 2 periods

Dear teacher please introduce your lesson by asking brain storming questions, like:

- Does Magnetic field create current?
- How can we induced current in a coil?

State the objective of your lesson

**Brainstorming question 4.4**

Yes, when there is relative motion between a magnet and a coil, wire current is induced in the wire.

**Presentation**

- Start the lesson by describing Faraday's Law of induction.
- Explain the practical application of electromagnetic induction to the real world where students can see and analyse it with their daily experiences.
- Ask to define magnetic flux which can be compared with electric flux, and finally write the mathematical equation for them.

- Ask when will be the magnetic flux maximum, minimum and zero, and then ask them why maximum, minimum and zero to understand the angle between the magnetic field and area cross-section plays the role.

**Summary**

You can summarize your lesson by revising the core points of your lesson like:

- Defining electromagnetic induction
- Defining magnetic flux
- Explain what will happen to the direction of the induced current when the polarity of the magnet is changed.

**Assessment**

You can evaluate the understanding of your students by asking question like:

- Define electromagnetic induction.
- At what condition is the magnetic flux maximum, minimum and zero; why?
- How is current induced in the coil ?

Select questions from exercise 4.4 and end unit problems and give as home work and class work. Provide feedback for each question.

**Exercise 4.4 Answer**

1) The total number of magnetic lines of force crossing the surface placed in a magnetic field normally

2)

Given: $A=200cm^2$

$B= 0.5T$

$\theta = 0^0$

$\Phi = BA\cos\theta$

$\Phi = 200x10^{-4}$ x $0.5T\cos 0^0 = 0.01Wb$

3) A. $0^0$

4) $\Phi = BA\cos\theta$

$\Phi = 2.5Tx\pi x4x10^{-4}\cos 0^0$

$\Phi = 10^{-3}\pi Wb$

**Activity 4.2**

Dear teacher this activity helps the student to easily understand electromagnetic induction.The materials needed for this activity are shown in the Figure 4.10. Coil wire, galvanometer and magnet. The galvanometer measures the small current induced in the coil. You can see the deflection of the pointer of the galvanometer when there is relative motion between the magnet and the coil. When the magnetic field moves through the coil magnetic force is applied on the free electrons in the wire and causing them to move which is called electric current.

## 4.5. Faraday's Law of electromagnetic Induction

This section requires approximately 2 periods

- Dear teacher you can introduce your lesson by asking your students to explain electromagnetic induction.
- State the objective of your lesson.

**Answer for brainstorming question 4.5**

Electric generators work on the principle of electromagnetic induction. A conductor coil (a copper coil tightly wound onto a metal core) is rotated rapidly between the poles of a magnet. When the coil rotates, it cuts the magnetic field which lies between the two poles of the magnet. The magnetic field will interfere with the electrons in the conductor to induce a flow of electric current inside it. An electric generator converts mechanical energy into electrical energy.

**Presentation**

Present your lesson by engaging your student with different activities:

- Support your explanation to Faraday‘s electromagnetic induction by Activity 4.2 .
- Ask students to reflect their understanding on what induces emf
- Then explain the experimental observations of the events observed in the previous experiments was formally organized as Law of electromagnetic induction
- Ask students also what will happen to the emf when the number of turns (N) increases.
- Work some problems in addition to solved problem in the student‘s text .

**Summary**

You can summarize your lesson by revising the core points of the lesson:

- State Faraday‘s law of electromagnetic induction.
- State Lenz‘law.

**Assessment**

Evaluate your students their understanding by asking some basic questions

- Ask students to state Faraday‘s law of electromagnetic induction
- Ask the to state Lenze‘s law in relation electromagnetic induction
- Ask them what happens to the magnitude of emf when the number of turns increases.

Select questions from exercise 4.5 and end unit problems and give as home work and class work. Provide feedback for each question.

**Exercise 4.5 Answer**

1) A. All

2) C. The rate of change of the magnetic flux in the coil.

3) C. Energy

4) B. False (The induced emf opposes the change in the magnetic flux not the magnetic flux.)

5)

From the Equation of Faraday‘s law:

The magnitude of the induced emf is given by:

## 4.6. Transformers

This section requires approximately 2 periods

- Dear Teacher  introduce your lesson by asking questions like:
- What is a transformer?
- Function of transformer?
- What is inside a transformer?

State the objective of your lesson

**Answer to brainstorming question  4.6:**

Any electrical or electronic device which operates at voltage less or greater than the voltage that is available at supply terminals can have inbuilt transformer. The transformer converts the power supply voltage to the voltage specified for the  device.  The best and simple example is cell phone charger.This charger has a step-down transformer. You can also list down appliances which use transformer as their voltage converter like Refrigerator, air Conditioners , computer etc.

**Presentation**

Dear teacher you can present your lesson by some of the following points:

- Ask students to reflect their observation where transformer is applicable
- Then define Transformer to students ,that: it is  electrical device that transfers electrical energy from one circuit to another through the process of electromagnetic induction.
- Ask students how transformer can increase and decrease voltage between circuits with out altering frequency.
- Explain to students that, Transformer transfer of electrical energy from circuit to another

- Describe that It transfers electric power without any change in frequency
- Working principle of transformer in house appliances.

**Summary**

You can summarize your lesson by revising the core points of the lesson:

- Define Transformer.
- Distinguish between step-up and step-down transformer.

**Assessment**

You can evaluate the understanding of your students by asking some basic question on Transformer and its working principle,like:

- Define transformer, how it increase and decrease the voltage between the circuit
- List down some of the devices available in your home ,school or office which uses transformer as their voltage converter.

Select questions from exercise 4.6 and end unit problems and give as home work and class work. Provide feedback for each question.

**Exercise 4.6: Answer**

1)

solving for $I_s$

2)

—

——=5.5

3)A transformer works on principle of electromagnetic induction.According to this principle a varying current(Ac current) of primary side of transformer creates varying magnetic flux in the transformer core and this induces varying magnetic field in the secondary side of transformer and it produces electromotive force(emf) on the secondary side of transformer.

## 4.7. Application and safety

This section requires approximately 4 periods

Dear teacher this section is related with the application and safety of electromagnetism; electrical, magnetic materials, that uses electromagnetism for their application:

- So, it can preferable to give them reading assignment to be reflected back to the class as a group work presentation and make class discussion with their classmates
- And then you can give them feedback on their report towards application and safety rules in practical engagement with the devices.
- Inform them to explain and identify application of electromagnetic inductions and possible precautions they should take when there is practical engagements.

## Answer for the unit end questions

1 I = 10 A, B = $8 \times 10^{-4}$ T

$\mu_0 = 4\pi \times 10^{-7}$ T.m/A

**2**.

where

( ) ( )

**3.** (a) The number of loops in the secondary is:

(b). Similarly the corresponding currrent in the secondary coil is given by:

**4. Given**: Number of turns = N =500, emf= 60v, $\Delta\Phi$=0.06Wb

**Solution:**

emf ——

———————

Δt=0.5s

**5.**

— —

—

—

**6. Solution**: the area of the circular loop is:

$A = \pi r^2 = (3.14)(0.20m)^2 = 0.1256m^2$

The flux passing through this area is $\phi = 1.9 \times 10^{-2}$Wb, the magnetic flux density (field strength) is then: – ————

**7.** Solution: $A = 3cm \times 2cm = 3 \times 10^{-2}m \times 2 \times 10^{-2}m = 6 \times 10^{-4}\, m^2$

the flux is then,

$\phi = BA = 0.1T \times 6 \times 10^{-4}m^2 = 6 \times 10^{-5}$ Wb

**8. Solution:** N = 1250,

$\phi_1 = 5mWb = 5 \times 10^{-3}Wb$

$\phi_2 = -5mWb = -5 \times 10^{-3}Wb$ (because the same flux is reversed)

$\Delta t = 0.125$ sec $= 125 \times 10^{-3}$ s

applying Farady's law, we find

**9.** Solution: a). to decide the type of the transformer we compare the out put to input voltage.

$P_{out} = V_{out}I_{out}$

$150W = V_{out} \times 5A$

$V_{out} = (150W)/5A = 30V$ s, it is a step up transformer because $V_{out} > V_{in}$

b).

**10.**

# Unit 5: Basic electronics

This unit should be completed approximately in 18 periods

**INTRODUCTION**

Dear teacher let the students mention the electronics devices they are using at home. Ask them to mention some components of electronic device. State the learning objectives of this unit.

**Brainstorming question 5.1 Answer**

- The most common components of electronics are capacitor, resistor, transistor, diode, etc.These electronic components are connected to each other and form electric circuit.

## 5.1 Semiconductors

This section requires approximately 2 periods

**Introduction**

Dear teacher revise with students what they already know about insulator and conductor. State the specific objectives of this lesson.

**Presentation**

Define electrical conductivity. Discuss the classification of materials based on their conductivity. Introduce the new term semiconductor. This section discusses the different types of semiconductor materials. Ask students to give example of pure and compound semiconductor materials. Introduce the concept of doping and hole as it is defined in the student text book. State the specific objectives of this section.

**Brainstorming question 5.2 Answer**

Conductors are materials which allow electricity to flow through them. Metals are good conductors of electricity. Conductors have free electrons that allow the easy flow of electric current.
Insulators do not have free electrons every electron in them is tightly bound to the parent atom.

Plastic, wood, glass and rubber are electrical insulators. Semiconductors are materials which have a conductivity between conductors and insulators. The conductivity of semiconductors increases with increasing temperature.

**Lattice Structure of Semiconductor**

Ask students to mention group IV elements. Discuss the special properties of these elements. Discuss the structure of Si and the bond type between the atoms of silicon as it is illustrated in Figure 5.1 in the student text book.

**Types of Semiconductors**

Discuss the classification of semiconductors into intrinsic and extrinsic semiconductors. The classification is based on impurities added.

**Intrinsic Semiconductor:**

Discuss intrinsic semiconductors and give example. Intrinsic semiconductors are composed of only one kind of material; silicon and germanium are two examples.

**Extrinsic Semiconductors:**

Discuss extrinsic semiconductors and give example. By the addition of certain selected impurities to the pure semi-conductor in a very small ratio the conductivity of semiconductor crystal can be remarkably improved. Emphasis that doping of semiconductors materials is to have the properties needed to work in electronic components. The main aim of doping is to make sure that there are either too many electrons (surplus) or too few (deficiency). The extrinsic semiconductors are further classified as N-type and P-type semiconductors, based on the type of impurity atoms added to the semi-conductors.

**N-Type Semiconductor:**

Ask students the number of electrons on the outer most shell of Group V elements. Discuss that an extra of electrons is created by adding an element that has more valence electrons than the intrinsic semiconductor. Explain how the doping of pure Si creates surplus electron when doped with Group V elements as illustrated in figure 5.3a in the student text book. The majority carriers are electrons and holes are minority carriers.

**P-Type Semiconductor:**

Ask students the number of electrons on the outer most shell of Group III elements.

Discuss when Group III element in the periodic table is added to a pure semiconductor, the covalent bond between the impurity and the pure semiconductor creates a hole (absence of electron). These holes are the majority carries and electrons are minority carries. Explain the

doping process as illustrated in figure 5.3b in the student text book. Help students to carry out Discussion question 5.1.

**Discussion Question 5.1 Answer**

1. In conductor free electrons are the carriers. In Semiconductors the current carriers are holes or electrons.
2. Boron is group III element. When it is doped with germanium excess holes are created and the type of semiconductor is P –type.
3. A) Phosphorus: N-tpe

   B) Gallium: P-type

   C) Arsenic: N-type dopant

   D) Indium: P-type dopant

**Summary**

Summarize this section by revising the following key points.

- Electronic components include resistors, transistors, capacitors, diodes, inductors, etc.
- These electronic components are connected to each other and form electric circuit.
- The conductivity of semi conductors can be increased by increasing temperature.
- Semiconductor materials are doped with Group III or V elements to increase their conductivity.
- Pure semiconductor materials doped with Group V elements are called N-type semiconductors
- Pure semiconductor materials doped with Group III elements are called P-type semiconductors
- The majority carriers in N-type semiconductors are electrons and holes are minority carriers.
- The majority carriers in P-type semiconductors are holes and electrons are minority carriers.

**Assessment**

Ask your students to explain the following basic concepts in this section

- Conductor
- Insulator

- Conductivity
- Semiconductor materials
- Intrinsic semiconductor
- Extrinsic semiconductor
- N-type semiconductor
- P-type semiconductor

Select questions from review questions 5.1 and end unit problems and give as home work and class work. Provide feedback for each question.

**Review questions 5.1 : Answer**

1) Conduction occurs at higher temperature because the electrons surrounding the semiconductor atoms can break away from their covalent bond and move freely about the lattice

2) A semiconductor doped with Group V elements such as phosphorus (P), arsenic (As), or antimony (Sb) as an impurity is N-type semiconductor. It has surplus of electrons. A semiconductor doped with Group III elements such as boron (B) or indium (In) is called p-type semiconductor.

3) A. Aluminium

4) C. pentavalent

5) B.p-type semiconductor

## 5.2 Diodes and their Functions

This Section requires approximately 3 periods

**Introduction**

Dear teacher ask students to mention an electronic component conducting one way and insulating in other way and let them to discuss its function. From their previous knowledge ask them the V-I relation of a resistor. State the specific objectives of this section.

**Brainstorming question 5.3 Answer**

A diode is a semiconductor device that essentially allows current to flow easily in one direction, but blocks current from flowing in the opposite direction.

**Presentation**

**The p-n junction Diode**

Dear teacher introduce this section by reminding the previous lesson about P-type and N-type semiconductor. Introduce a p-n junction diode, it is a p-type and n-type semiconductors are placed in contact with each other. Discuss the depletion layer as illustrated in Figure 5.5a in the student text book.

**Biasing of P-N junction diode**

Discus applying a suitable DC voltage to a diode is known as biasing. No bising with out external voltage. It can be done in two ways: Forward and Reverse biasing.

**Forward biased**

Discuss forward biasing as illustrated in Fig 5.6 in the student text. Ask student how the carriers are flowing through the diode for this type of connection. Explain the current flow through the diode for this type of connection when the battery voltage increases.

**Reverse biased**

Discuss reverse biasing as illustrated in Fig 5.7 in the student text. Ask student how the carriers cannot flow through the diode for this type of connection. Compare the size of the depletion region width than in an unbiased or forward-biased diode. Check the students understanding that biasing is when the diode is connected to battery. Let the students to discuss discussion question 5.2.

**Discussion Question 5.2 Answer**

1. Biasing is associated to battery voltage.
   - When the negative terminal of the battery is connected to the P-type semiconductor and the positive terminal to the N-type semiconductor of the P-N junction diode, the P-N junction diode is said reverse biased
   - When the positive terminal of the battery is connected to the P-type semiconductor and the negative terminal to the N-type semiconductor of the P-N junction diode, the junction is said to be forward biased
2. Diodes in both forward and reverse bias are useful for computer chips, solar cells, and other electronic devices.

**Current-voltage characteristics of the semiconductor diode**

Dear teacher discuss Semiconductor diodes are characterized by non-linear current–voltage characteristics as illustrated in Figure 5.8 in student text book. The I-V characteristics curves reflects the operation of PN junction diode. Then these devices have non-linear I-V characteristics, as opposed to resistors which have a linear relationship between the current and voltage.

**Summary**

Summarize this section by revising the following key points.

- A diode is a two-terminal electronic component that only conducts current in

one direction.

- When an n-type semiconductor is joined with the p-type semiconductor, a p-n junction diode is formed.
- The combination of electrons and holes near the junction creates a narrow region in the vicinity of the junction called depletion region.
- Applying a suitable DC voltage to a diode is known as biasing.
- When the positive terminal of the battery is connected to the P-type semiconductor and the negative terminal to the N-type semiconductor, the P-N junction. diode is said to be forward biased.
- When the negative terminal of the battery is connected to the P-type semiconductor and the positive terminal to the N-type semiconductor, the P-N junction diode is said to be reverse biased
- Semiconductor diodes are characterized by non-linear I–V characteristics

**Assessment**

Ask your students to explain the following basic concepts in this section

- PN junction diode
- Depletion layer

- Biasing of PN junction diode
- Forward bias
- Reverse bias
- I-V characteristics of PN junction diode.

Select questions from review questions 5.2 and end unit problems and give as home work and class work. Provide feedback for each question.

**Review questions 5.2 answer:**

1) A diode is a semiconductor device that essentially acts as a one-way switch for current. It allows current to flow easily in one direction, but blocks current from flowing in the opposite direction.

2) True

3) Holes and electrons

4) When P side is connected + side of a battery and N side is connected to negative side of a battery, is called forward bias. When P side is connected – side and N side are connected to positive is called reverse bias.

5) Current and voltage

6) B. (Recombination of electron-hole)

## 5.3 Rectification

This Section requires approximately 3 periods

**Introduction**

whether we use AC or DC it depends on the electronic circuit needs and purpose. There are some electronic circuits which use DC only.Therefore a rectifier is used for the conversion of AC to DC.

**Presentation**

Define rectification. Discuss the two types of rectification of diodes as it is illustrated in figure 5.9 and 5.10 in the student text book.

**Half wave rectification**

Define half wave rectifier. Discuss the working principle of half wave rectifier for both positive half cycle and negative half cycle using the circuit diagram Figure 5.9 in the student text book

**Full wave bridge Rectification**

Discuss full wave rectifier. Discuss the working principle of full wave rectifier for both positive half cycle and negative half cycle using the circuit diagram figure 5.11 in the student text book. . Ask students to compare the output voltage of full-wave rectifier and half wave rectifier.

**Diodes and Capacitor**

Discuss rectifiers make the output current unidirectional but the magnitude is still not constant. Capacitors are connected in the circuit to make the magnitude smooth or constant as shown in figure 5.12 in student text book.

**Practical uses of diodes**

Discuss the practical uses of diodes which are mentioned in the student text book.

**Discussion Question 5.3: Answer**

In half wave rectifier only 50% AC power passes through the diode.

**Summary**

Summarize this section by reminding the following key points:

- The process in which an AC voltage is converted into a unidirectional (D.C) voltage is known as rectification.
- A P-N junction diode used to rectify alternating voltage (A.C). The process is called rectification.
- A half wave rectifier allows one half-cycle of an AC voltage waveform to pass by blocking the other half-cycle.
- A full wave rectifier allows both cycle of an AC voltage to pass.
- Capacitor is used in rectifier circuits to smooth the fluctuations of the output voltage.
- Diodes have different practical applications such as light emitting diode (LED), photo diode, logic gate,Over voltage protection.

**Assessment**

You can evaluate your students by raising a question on the following conce**pts:**

- rectification
- half-wave rectifiers,
- full-wave rectifiers
- Capacitor
- LED

- Photo diode

Select questions from review questions 5.3 and end unit problems and give as home work and class work. Provide feedback for each question.

**Review questions 5.3 answer:**

1) Rectification is the conversion of alternating current (AC) to direct current (DC). This involves a device that only allows one-way flow of electric charge.

2) Resistance is a measure of the opposition to current flow in an electrical circuit.

Capacitor: It is a component that stores charge and then discharges it into the circuit when there is a drop in current.

3) A. The load current.

4) C. It utilizes both half-cycle of the input.

## 5.4 Transistors and their application

This Section requires approximately 3 periods

**Introduction**

Transistor are two types; bipolar Junction Transistors (BJT) and Field Effect Transistors (FET). Dear teacher in this section the bipolar junction transistor will be covered. Discuss transistor is a three terminal two-junction device used to control electron flow. By varying the amount of voltage applied to the three terminals, the amount of current can be controlled. State the specific objectives of this section.

**Presentation**

Define emitter, collector and base. Discuss the two arrangements of transistors and the symbol for each arrangement. Emphasis the arrow in the symbols show the direction of the conventional current (hole current). Compare the doping amount of the three regions.

**Basic Transistor operation**

NPN Transistor

Discus with students the following concepts:

- The second PN junction is required to be reverse biased for proper transistor operation..
- The collector must be connected to an opposite polarity voltage (positive).
- The voltage on the collector must also be more positive than the base.

- Emitter current, base current, collector current.
-

PNP Transistor

Discuss with student the following concepts:

- The bias batteries are reversed for the PNP transistor compared to NPN transistor.
- The base-collector junction is always reverse biased, then the opposite polarity voltage (negative) must be used for the collector.
- The base of the PNP transistor must be negative with respect to the emitter, and the collector must be more negative than the base.

**Discussion Question 5.4 Answer**

1. A diode has two regions: P and N. It has two terminal. A transistor has three regions (layers): PNP or NPN and three terminals.
2. NPN and PNP
3. Emitter, collector and base

- The Emitter supplies a large number of charge carriers in to the base.It is heavily doped.
- The collector removes charges from its junction with the base
- The base is lightly doped and very thin. And it can pass most of the emitter injected charge carriers to the collector.

**Transistor Configurations**

Dear teacher discuss the following concepts:

- There are three possible ways to connect a transistor within an electronic circuit:the Common Emitter (CE), the Common Base (CB) Configuration, the Common Collector (CC)
- Each method of connection responding differently to its input signal within a circuit as the characteristics of the transistor varies with each circuit arrangement.

**Discussion Question 5.5 Answer**

1. Base terminal
2. Common emitter
3. Common Collector: Current gain.

Common Base: Voltage and power gain.

Common Emitter: Current and power gain.

**Summary**

Summarize this section by reminding key concepts.

- The emitter in NPN transistor is connected to the negative terminal of the battery while the base is connected to the positive terminal.
- The emitter junction is forward biased and the collector junction is reverse biased.
- The collector must be connected to an opposite polarity voltage (positive).
- The voltage on the collector must also be more positive than the base.
- The base of the PNP transistor must be negative with respect to the emitter, and the collector must be more negative than the base.
- Amplification is the process of increasing the input weak power, current or voltage of an AC signal.
- The formula used to describe the behavior of a bipolar transistor is:

—

- The gains (β ) is the amount of amplification in a circuit.

**Assessment**

You can evaluate your students by asking questions on the following concepts:

- Forward biased and Reverse biased.
- The majority carriers in NPN or PNP transistor.
- Connection of PNP transistor with voltage.
- Transistor configarations
- Amplification
- The gains (β )
- Give homework and classwork and provide feedback.

Select questions from review questions 5.4 and end unit problems and give as home work and class work. Provide feedback for each question.

**Review questions 5.4 answer**

1) A transistor is a semiconductor device used to amplify electrical signals and acting as a switch/gate.

2) Emitter current is the largest and base current is the smallest.

3) A. Lightly doped.

4) Emitter-base is forward bias and base-collector is reverse base.

5)

$$\frac{}{} = \frac{}{} = 0.1\text{mA}$$

## 5.5 Integrated Circuits

This Section requires approximately 1 periods

**Introduction**

Dear teacher introduce the term integrated circuit. An integrated circuit (IC) (also referred to as a chip, or a microchip). The circuit consists of diodes, transistors, resistors, and capacitors. . The goal of the integrated circuit is to develop a single device to perform a specific function, such as amplification or switching, microprocessor, timer, as computer memory, eliminating the separation between components and circuits. State the specific objectives of this section.

**Presentation**

**Dear teacher discuss the following concepts:**

- The circuit consists of diodes, transistors, resistors, and capacitors.
- The most obvious advantage of the integrated circuit is its small size.
- This small integrated circuit consumes less power and operates at higher speeds.
- In the integrated circuit, internal components are connected permanently.

**Summary**

You can summarize this section by reminding the following concepts:

- The circuit consists of diodes, transistors, resistors, and capacitors.
- The most obvious advantage of the integrated circuit is its small size, high speed and consume less power
- In the integrated circuit, internal components are connected permanently.
- Integrated circuits reduce the number of parts needed to construct electronic equipment.

**Assessment**

You can evaluate the students by asking questions on the following concepts:

- Integrated circuit
- Components of integrated circuit
- advantage of the integrated circuit

## 5.6 Logic gates and logic circuits.

This Section requires approximately 3 periods

**Introduction**

Dear teacher you can ask the following question to motivate your students before you start the lesson.

**Brain storming question 5.4 Answer**

- What mechanism is used to record and store video and audio information including musical sounds we often watch or listen?

Using a computer, any information can be turned into a pattern of 0 and 1. Pictures, recorded music, text and motion pictures can all be turned into a string of 0s and 1s and transmitted or stored in the same way. The computer receiving the signal at the other end converts it back again. A Compact Disc (CD) for example, can store music or text or pictures, and all of them can be read using a computer. Using the 0s and 1s you do all kinds of mathematics. This is what computers do. Computer understands information in 0 and1 off and on.

**Analog and digital signals**

**Presentation**

Dear teacher ask students the difference between analog and digital signal. Let the student discuss this topic based on figure 5.24.

Discuss the following concepts with students:

- A signal is a function that conveys information about a phenomenon (energy, force, torque, light, motion, position, sound, temperature, etc.).
- In electronics and telecommunications, signal refers to any time varying voltage, current, or electromagnetic wave that carries information.
- Two main types of signals encountered in practice are analog and digital.
- An analog signal is any continuous signal representing some time-varying quantity.
- A digital signal is a signal that is being used to represent data as a sequence of discrete values.
- In most digital circuits, the digital signal can have two possible valid values; this is called a binary signal or logic signal. They are represented by two voltage bands. It is either high, or it is low. It never has any other value.
- The low voltage level is written 0, while the high voltage level is written as 1.
- Using a computer, any information can be turned into a pattern of 0s and 1s.
- Pictures, recorded music, text and motion pictures can all be turned into a string of 0s and 1s and transmitted or stored in the same way.

**Positive and Negative Logic**

**Dear teacher discuss the following logic gate concepts:**

- In computing system, the binary number symbols ~~"0"~~ and ~~"1"~~ represent two possible states of a circuit or an electronic device.
- In positive logic, the 1 represents: an *On* circuit, a *Closed* switch, a *High* voltage, a *Plus* sign and a *True* statement.
- Consequently, the 0 represents: an *Off* circuit, a *Opened* switch, a *Low* voltage, a *Minus* sign and a *False* statement.
- In Negative logic, the 0 represents: an *On* circuit, a *Closed* switch, a *High* voltage, a *Plus* sign and a *True* statement.

- Consequently, the 1 represents: an *Off* circuit, a *Opened* switch, a *Low* voltage, a *Minus* sign and a *False* statement.

**Logic gates**

Dear teacher ask students their previous knowledge about logic gate. Then discuss the following concepts:

- An integrated circuit is a collection of logic gates.
- The logic gates are building blocks of digital electronics.
- Each logic gate is made of many microscopic transistors connected together within a thin wafer of silicon.
- Logic gate is a digital circuit which works according to some logical relationship between input and output voltage.
- The logic gate may have one or more inputs, but only one output.
- The logical statements that logic gates follow are called ―Boolean expressions".
- Explain each of the OR,AND,NOT,NOR and NAND gate.
- Mention the applications of these gates.
- Discuss the worked examples with students.

**Exercise 5.2 (Ans)**

| A | B | C | D | E |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 1 | 1 | 1 |
| 1 | 0 | 1 | 0 | 0 |
| 1 | 1 | 1 | 1 | 1 |

**Exercise 5.3 Ans**

| A | B | C | D | Q |
|---|---|---|---|---|
| 0 | 0 | 1 | 1 | 0 |
| 0 | 1 | 0 | 0 | 1 |
| 1 | 0 | 1 | 0 | 1 |
| 1 | 1 | 0 | 0 | 1 |

**Exercise 5.4 (Answer)**
A) NAND B) NOR

## 5.6 Application of Electronics

This Section requires approximately 3 periods

Dear teacher ask students to mention devices in their living area which perform specific task that use electricity for its operation. The task may be transmitting information controlling other machine, displaying information, storing information, and many more.

**Brainstorming question 5.5 Answer**
Students can mention like: TV, Computers, Mobile phone, Radio, Oven, washing machine, etc.

Discuss some of the applications of electronic which are explained in the student text book: Aerospace industry, Medical, Automobile, Utility system, commercial, agriculture, communication, Industrial, residential and military. Let students discuss in group activity 5.9.

**Summary**
Dear teacher you can Summarize section 5.6 and 5.7 by reminding the following key points:

- A signal refers to any time varying voltage, current, or electromagnetic wave that carries information.
- There are two types of signals: analog and digital.
- An analog signal is continuous signal representing some time-varying quantity.
- A digital signal is a signal that is being used to represent data as a sequence of discrete values.
- In most digital circuits, the digital signal can have two possible valid values; 0 and 1. this is called a binary signal or logic signal.
- The low voltage level is written 0, while the high voltage level is written as 1.
- Using a computer, any information can be turned into a pattern of 0s and 1s.
- An integrated circuit is a collection of logic gates.
- Each logic gate is made of many microscopic transistors connected together within a thin wafer of silicon.
- The logical statements that logic gates follow are called ―Boolean expressions".
- There are different logic gates: OR,AND,NOT,NOR and NAND.

**Assessment**

You can evaluate the students by asking questions on the following concepts;

- Analog and Digital signal
- Representing analog and digital signal.
- A binary signal or logic signal.
- high voltage and low voltage
- Information in a computer as 0 and 1.
- Integrated circuit
- Logic gates.
- OR,AND,NOT,NOR and NAND logic gates

Give homework and class work and provide feedback.

**Project**

Dear teacher assist students to identify and classify the collected different types of diodes. Help them how they can get additional devices from physics lab for the intended purpose. Encourage them to show their functional device and explain the working principle.

## Answer for the unit end questions

1.
   - Pure semiconductor materials doped with Group V elements are called N-type semiconductors.
   - Pure semiconductor materials doped with Group III elements are called P-type

2.
   - Semiconductor materials doped with Group V elements have surpulse electrons and these electrons are majority carriers.
   - Semiconductor materials doped with Group III elements have deficiency of electrons or excess of holes. The carriers are holes.

3. When p-type and n-type semiconductors are placed in contact with each other, a p-n junction p-n junction diode is formed.
4. In halfe-wave rectification a half-cycle of an AC voltage waveform to pass by blocking the other half-cycle. A full wave rectifier is a rectifier that converts the complete cycle of alternating current into pulsating DC.

5. The emitter-base junction is forward biased and the collector-base junction is reverse biased.
6. The common use of transistor is amplification or switch
7. From the base to emitter
8. Positive voltage is applied to the collector and the base connected to negative terminal to the base collector voltage.
9. The base region is made very thin
10. Amplifier
11. Input and output signals are $180^0$ out of phase.
12. 

IB=4.2mA-4mA=0.2mA

 =20

13. 0 and 1

logic gate

14. An analog signal is any continuous signal representing some time-varying quantity.

A digital signal is a signal that is being used to represent data as a sequence of discrete values.

15. Logic gate is a digital circuit which works according to some logical relationship between input and output voltage. It is a building blocks of digital electronics.
16. Write out the truth table for the following circuit. Which single gate is this circuit equivalent to?

| A | B | Y‘ | Y |
|---|---|---|---|
| 0 | 0 | 0 | 1 |
| 1 | 0 | 0 | 1 |
| 0 | 1 | 0 | 1 |
| 1 | 1 | 0 | 0 |

OR

| A | B | Y |
|---|---|---|

| | | |
|---|---|---|
| 0 | 0 | 1 |
| 1 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 1 | 0 |

17.

| A | A‘ | B | B‘ | Y |
|---|---|---|---|---|
| 0 | 1 | 0 | 1 | 1 |
| 1 | 0 | 1 | 0 | 1 |
| 0 | 1 | 0 | 1 | 1 |
| 1 | 0 | 1 | 0 | 0 |

This can be represented by a single OR-gate.

18 The AND operation is written as multiplication and an OR operation is written as addition.

19. In positive logic, the 1 represents: an On circuit, a Closed switch, a High voltage, a Plus sign and a True statement. Consequently, the 0 represents: an Off circuit, a Opened switch, a Low voltage, a Minus sign and a False statement. In Negative logic, the 0 represents: an On circuit, a Closed switch, a High voltage, a Plus sign and a True statement. Consequently, the 1 represents: an Off circuit, a Opened switch, a Low voltage, a Minus sign and a False statement.

20. The NAND gate and is Boolean Expression is show as follow.