# Physics Syllabus
# For
# Grade 12

## Grade 12 physics objectives

**After completing grade 12 physics lessons the students will be able to:**

- understand the laws of thermodynamics, thermodnyamical processes, work and heat in thermodynamic processes, heat engines, reversible and irreversible processes
- develop skills in applying the laws of thermodynamics to describe physical phenomenon,
- acquire knowledge about waves and oscillations, periodic motion, simple harmonic motion, standing waves, intensity and loudness and the human ear
- Understand the concepts of, electrical, gravitational, and magnetic fields; electromagnetic radiation; electromagnetic induction, and the interface between energy and matter, the common applications of electrical and electronic circuits, and the function and configuration of components used in the circuits
- Develop skills in using measuring instruments and common electrical devices ;constructing simple electrical circuits using common tools appropriately and safely
- Appreciate the applications of electrical and electronic technologies to the humanity
- Acquire knowledge and understanding of the dual nature of matter and radiation, photo electric effect, atoms and nuclei,radioactivity,mass defect, nuclear fission and fusion

## Unit 1: Thermodynamics *(15 periods)*

***Unit outcomes*****:** Students will be able to:

- acquire knowledge and understanding in the laws of thermodynamics, reversible and irreversible processes and heat engines
- understand that the work done by a heat engine that is working in cycle is the difference between the heat flow into the engine at high temperature and the heat flow at a lower temperature
- identify the internal energy of an object includes the energy of random motion of the object's atoms and molecules
- solve problems involving heat flow, work, and efficiency in a heat engine and know that all real engines lose some heat to their surroundings
- know that heat floe and work are two forms of energy transfer between systems
- understand ideal- gas processes and represent them on a PV diagram, adiabatic processes, the properties of a macroscopic system in terms of the microscopic behaviour of molecules.

| ***Competencies*** | ***Contents*** | ***Suggested Activities*** |
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| *Students will be able to:*<br>• Define the terms Atomic mass, mole, molar mass and Avogadro's number<br>• Use the relationship between number of moles (n) number density (N) and Avogadro's number (N) to solve some related problems<br>• Draw phase diagram to determine triple- point for some common substances<br>• Differentiate between critical point and boiling point of a substance | ***1. Thermo dynamics***<br>**1.1. Thermal equilibrium and definition of temperature (zeros law of thermodynamics)**<br>*(1 period)*<br>• Solids, liquids and gases<br>• Atoms and moles<br>• Temperature<br>• Zeroth law of thermodynamic<br>• Phase change | Start with a few basic thermodynamics concepts, namely how temperature is measured, what temperature scales are, and what is meant by heat. And then begins the discussion of the relationship between heat and temperature.<br>Make an emphasis on the fact that physicists do **not** say an object has heat. Heat refers solely to the flow of energy due to temperature differences. Heat transfers *thermal energy* that is internal to objects, related to the random motion of the atoms making up the objects. Heat is like work: It changes the energy of an object or system. It does not make sense to say "how much work a system has", nor does it make sense to say "how much heat the system has". Just as work is done by a system or on a system, heat as thermal energy can enter a system or leave a system. |
| • State the assumptions made to define an ideal gas<br>• Use the ideal gas law PV=nRT to solve related problems | **1.2. Work, heat and the first law of thermodynamics**<br>*(4 periods)*<br>• Ideal gas | • Let the students in group design a process that will decrease the pressure in the gas cylinder without changing the volume; a process that will increase the volume in the gas cylinder without changing the temperature. let them show the processes on a pV diagram.<br>Illustrate rapid cooling of gas upon expansion by making dry ice with carbon dioxide fire extinguisher. dry ice collects on several layers of cloth held over end of nozzle<br>Use light bicycle pump with metal case to inflate tire or foot ball. Rapid rise in metal case |

| ***Competencies*** | ***Contents*** | ***Suggested Activities*** |
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| • Define the scientific terms: isothermal, isobaric, isochoric, adiabatic processes<br>• calculate work and heat for ideal- gas processes<br>• Draw P-V diagram for an Isobaric, Isothermal and Isochoric process<br>• Define internal energy of a gas work done by /on a gas and a heat added/ removed<br>• state the first law of thermodynamics<br>• Describe ways of changing internal energy of a gas<br>• Use proper sign convention for work done(W) change in internal energy (U) and amount of heat energy (Q)<br>• Draw P-V diagram and calculate work done by/ on a gas from the graph<br>• Solve problems related to the first law<br>• Identify the appropriate form of the 1st law of thermodynamics for isobaric , isochoric and isothermal process<br>• Draw P-V diagram for Isobaric, Isochoric and Isothermal process and calculate work done for | • Ideal gas processes<br>• Work , heat and internal energy<br>• The first law of Thermodynamics<br>• First law of thermodynamics in Isobaric, Isochoric and isotherms process<br>• Molar heat capacity of gases | temperature is due more to compression work converted to heat than to piston friction. confirm by comparing case temperature after say,20 strokes, in 30 seconds 20 strokes in 60 seconds. |

| *Competencies* | *Contents* | *Suggested Activities* |
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| each case from the graph<br>• Define molar specific heat as a proportionality constant that relates the amount of heat flow per mole to a material's change in temperature<br>• Distinguish between molar heat capacity at a constant pressure ($c_p$) and molar heat capacity at a constant volume ($c_v$)<br>• Show that $c_p > c_v$ based on Meyer's equation $C_p – C_v = R$<br>• Identify that $c_{p/} c_v = 1.4$<br>• atomic gases and 1.67 for monatomic gase<br>• Distinguish between Isotherms and a diabetes in a p-v curve<br>• Use the fact that $TV^{\gamma-1}$ is constant for adiabatic process to solve related problems<br><br>• state the second law of thermodynamics<br>• describe ways of changing the internal energy of a gas<br>• apply the laws of thermodynamics to solve simple numerical problems<br>• solve problems involving | | |

| ***Competencies*** | ***Contents*** | ***Suggested Activities*** |
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| calculations of pressure, temperature or volume for a gas undergoing adiabatic changes<br>• Solve problems involving calculations of P,Vor T for a gas undergoing adiabatic changes<br>• Show that the molar heat capacity at constant pressure is greater than the molar heat capacity at constant volume<br>• Evaluate Cp-Cv and Cp/ Cv for an ideal gas | | |
| • Describe the kinetic theory of gases<br>• Derive the relation which relates gas pressure,volume,and kinetic energy $(PV=N/3mv^2{}_{av=2/3NKE})$<br>• Derive the kinetic theory formula as $KE_{av}=(3/2)kT$<br>• Define rms velocity of a gas<br>• Describe Brownian motion and diffusion as evidences to support the kinetic theory<br>• Define the mean– free-path (λ) as the average distance between collision of molecules<br><br>• Use the expression for | **Kinetic theory of gasses** *(3 periods)*<br><br>• Brownian motion<br>• Diffusion<br>• Mean-free path | Experiments<br>1. The Java applet from http://jersey.uoregon.edu/vlab/Piston/index.html will help you to do a series of virtual experiments;<br>You will control the action of a piston in a pressure chamber which is filled with an ideal gas. The gas is defined by four states: Temperature; Volume or density; Pressure and Molecular Weight There are 3 possible experiments to do. In the third experiment, labeled Ideal Gas Law, you can select from the Red, Blue or Yellow gas containers. Each gas in those containers has a different molecular weight and hence each will respond differently under changing pressure conditions.<br>Demonstration(s):<br>1. Java applets like the one available from http://lectureonline.cl.msu.edu/ mp/kap10/cd283.htm Helps students to understand the effect of temperature and volume on the number of collisions of the gas molecules with the walls. In the applet, there is a provision to change the temperature and volume with the sliders on the left side. The time for which the simulation runs can also be adjusted. The applet counts all collisions and displays the result after the run. By varying temperature and volume and keeping track of the number of collisions, students can grasp of what the main result of kinetic theory will be.<br>Project Work(s)<br>1. Heat capacity determination can be proposed by a home-made calorimeter and a thermometer. The heat capacity of a body is determined with the help of a calorimeter and a thermometer. A simple calorimeter consists of a polished metallic cylinder placed into another metallic cylinder on corks (for thermal insulation) The inner cylinder is filled with water or |

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| the pressure of an ideal gas in terms of its density and mean square speed of molecules to solve problems<br>• Solve problems to determine P,V,T or r.m.s speed of gas molecules for an ideal gas, given relevant data<br>• State Graham's law of diffusion<br>• Use Graham's law to solve related problems<br>• State Dalton's law of partial pressure<br>• Use Dalton's law in solving related problems | • Graham's law of diffusion<br>• Dalton's law of partial pressure | some other liquid of known specific heat. A body of mass m, and specific heat capacity c, heated to a certain temperature Ti is immersed in the calorimeter of mass m1, and specific heat capacity c1, in which the temperature is measured. Suppose that the temperature of the liquid of mass m2, and specific heat capacity c2, in the calorimeter is T 0 before the body is immersed in it, and when the temperatures of the liquid and the body are equal, the temperature becomes Tf. From the law of conservation of energy and assuming the heat given away by the hot object Q, the heat taken away by water and the calorimeter the calorimeter to be respectively and respectively show that the specific heat capacity of the body is<br>c =c1m1(Tf – T 0) + c2m2(Tf – T 0)/m(T – Tf)<br>=(c1m1 + c2m2) (Tf – T 0)/m(T – Tf)<br><br>• Give examples of irreversible processes as<br>Stirring blends your coffee and sugar, it never unmixes them. A plant in a sealed jar dies and decomposes to carbon and various gasses; the gases and carbon never spontaneously assemble themselves into a flower. They each show a clear direction of time, a distinct difference between past and future.<br>Experiment:<br>Cooling curve: The relationships between temperatures of a body (like hot water or liquid in calorimeter) with time. Find the slope of curve at four different temperatures of hot body and hence deduce Newton's law of cooling<br><br>**Project work:**<br>Students may investigate and report on the working principles of different types of practical thermometers such as clinical thermometer, oven thermometers, boiler thermometers and temperature gauge in a car |
| • distinguish between reversible and irreversible processes<br><br>• Discover that the second law of thermodynamics places sharp constraints on the maximum possible efficiency of heat engines and refrigerators<br>• describe the fundamental principles of heat engine and refrigerators | **Second law of thermodynamics , efficiency, and entropy** *(4 periods)*<br><br>• Reversible and irreversible processes<br><br>**1.5 Heat engines and refrigerators** *(3 periods)* | Contrast between mechanics and thermodynamics.<br><br>Using the engine as the basis of much of the discussion, focus on two topics. One topic is the first law of thermodynamics, the relationship between the energy supplied to an engine and how much work it does. The other topic is the role of gases in the functioning of an engine. Many engines use a gas to function; applying some basic principles of how gases behave proves very useful in understanding the functioning of engines.<br><br>In analyzing the processes in an engine cycle, In addition to the first law of thermodynamics, the ideal gas law is very useful. Here, briefly review this law, and show how it is used in analyzing heat engines. |

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| • Draw a P-V diagram for a cyclic process<br>•<br>• solve problems involving heat flow, work, and efficiency in a heat engine<br>• identify that all real engines lose some heat to their surroundings<br>• Define the term Entropy as a measure of the disorder of the system<br>• State the 2nd law of thermodynamics in terms of entropy<br>• Investigate the physical principles that all heat engines and all refrigerators must obey | • Order versus disorder<br>• Entropy | |

## Assessment

The teacher should assess each students work continuously over the whole unit and compare it with the following description, based on the competencies, to determine whether the student has achieved the minimum required level.

**Students at minimum requirement level**

A student working at the minimum requirement level will be able to: define the terms system, surrounding, state thermal equilibrium, internal energy, reversible process ,irreversible process ;state the zeroth law of thermodynamics ,the first law of thermodynamics and the second law of thermodynamics qualitatively and quantitatively; Solve problems related to the first and second laws of thermodynamics ;describe the working mechanisms of heat engines and refrigerators; solve problems involving thermodynamic processes; Describe ways of changing the internal energy of a gas; Describe the fundamental principles of heat engine;**-** Solve problems involving calculations of P,V or T for a gas undergoing adiabatic changes; Use the expression for the pressure of an ideal gas in terms of its density and mean square speed of molecules to solve problems; Solve problems to determine P, V, T or r.m.s speed of gas molecules for an ideal gas, given relevant data; Show that the molar heat capacity at constant pressure is greater than the molar heat capacity at constant volume; Evaluate Cv – Cv, and Cp/CV for an ideal gas.

**Students above minimum requirement level**

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

**Students below minimum requirement level**

Students working below the minimum requirement level will require extra help if they are to catch up with rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

## Unit 2: Oscillations and waves *(18 periods)*

***Unit outcomes***: Students will be able to:

- Identify the characteristic properties of waves: interference (beats), diffraction, refraction, Doppler effect,
- demonstrate an understanding of the properties of mechanical waves and sound and the Principles underlying the production, transmission, interaction, and reception of mechanical Waves and sound
- investigate the properties of mechanical waves and sound through experiments, and compare predicted results with actual results
- describe and explain ways, in which mechanical waves and sound are produced in nature, and evaluate the contributions to entertainment, health, and safety of technologies that muse of mechanical waves and sound..

| *Competencies* | *Contents* | *Suggested Activities* |
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| *Students will be able to:*<br>• describe the periodic motion of a vibrating object in qualitative terms, and analyze it in quantitative terms (e.g., the motion of a pendulum, a vibrating spring, a tuning fork)<br>• Define SHM as motion that follows a repetitive pattern, caused by a restoring force that is proportional to displacement from the equilibrium position<br>• Describe the relationship between uniform circular motion and simple harmonic<br>• Derive expression for displacement (x) velocity (v) and acceleration (a) of a body in an S HM as a function of time $x(t) = A\cos(\omega t + \varphi)$, $a(t) = -A\omega^2 \cos(\omega t + \varphi)$ | ***2. Oscillation and waves***<br>**2.1. Periodic motion (Basic concepts)** *(7 periods)*<br>• SHM and its equation<br>• Oscillation of a spring<br>• Simple pendulum<br>• Angular harmonic motion<br>• Physical pendulum | The study of both sound and optics is based on knowledge of the nature of waves.<br>On lectures emphasis should be on the fact that energy can be transmitted in only two ways – either by transfer of particles or by waves. Stress that all waves have the same general properties and follow the same laws i.e. there is only one set of rules of wave behavior that need be learned.<br>The teacher can point out the relationship of velocity and displacement by reviewing the role of force in SHM.<br>Focus on the key point that for SHM to occur, the net force on an object has to be proportional and opposite in sign to its displacement. Again, use the example of a mass attached to a spring on a friction-free surface, like an air hockey table.<br>Encourage students to be exposed (subjected) to three trigonometric functions, and three graphs, for the displacement, velocity and acceleration of an object in simple harmonic motion. All of these equations use the sine or cosine function; these are called *sinusoidal functions*. Show the equations.<br>Confirm the relationship between uniform circular motion and SHM qualitatively and quantitatively.<br>Students should realize that waves can be as plain to see as the ripples in a pond or as invisible as the electromagnetic waves emanating from a cellular phone. Mechanical waves, like those in a pond, require a medium in order to propagate. Electromagnetic waves – including radio waves and light – require no medium and can travel in the near vacuum of space. Electromagnetic waves rely on the interaction of electric and magnetic fields to propagate through space.<br>Students should understand that mechanical waves are vibrations in a medium, traveling from place to place without causing any net movement of the medium. Associate the lesson with “the wave” in a football or baseball stadium. The wave travels around the stadium, the result of spectators standing and then sitting in a rolling succession. As the fans oscillate up and down, they create what is called a *disturbance* or *waveform*. The location of the disturbance changes as the wave moves through the stadium, but the wave’s medium, the crowd, stays put. |

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| • <br>• Derive the expression for the period of any harmonic oscillator.<br>• Use Newton's 2nd law and Hooke's law to derive the expression $\omega=\sqrt{k/m}$<br>• Draw and analyze x-t,v-t and a-t curves for an SHM<br>• Derive and use expressions for the frequency and periodic time of oscillations of objects performing simple harmonic motion<br>• Distinguish between free and damped oscillations<br>• Define forced oscillations<br>• State the condition for resonance to take place($\omega = \omega_n$)<br>• Describe the effects of damping & forced oscillation<br>• Give some natural examples in which resonance takes place<br>• Describe the effects damping, forced oscillations and resonance analyze the components of resonance and identify the conditions required for | • Free, Forced and damped oscillation<br>• Resonance<br>• Energy in SHM | A wave in a stadium is a useful example, but it is not a true mechanical wave.<br>Students should appreciate that in both transverse and longitudinal waves, the particles do move, but there is no **net** motion of the particles after each cycle. A particle moves up and down, or back and forth, but it returns to its initial position. It oscillates like a mass attached to a spring.<br>Students should appreciate that a wave's amplitude is related to the energy it carries. Waves with greater amplitude carry more energy. They can experience this relationship at the beach; they may barely notice a small-amplitude wave crashing into you, while a large-amplitude wave may knock you off your feet!<br>The teacher should demonstrate a wave in which the particles oscillate in simple harmonic motion. An equation that includes the sine function is used to describe a particle's displacement. The equation relates the vertical displacement of the particle to various factors: the horizontal position of the particle, the elapsed time, and the wave's amplitude, frequency and wavelength. When all these factors are known, the vertical position of a point can be determined at any time *t*.<br>$Y= A \sin(2\pi x/\lambda - 2\pi ft)$<br>Draw a diagram of a snapshot of a wave that started at the left and traveled along a stretched string for 3.00 seconds. Ask students to use the equation that describes a traveling wave that exactly matches the target wave.<br><br>Students should use wave equation and wave –speed equation to solve sample problems in their text books.<br>Given the motion of a particle of a wave plotted against a time scale, let students answer the frequency *f* and the period T of the wave by looking at the graph and noting the time elapsed between two points.<br>Experiments and Demonstrations are absolutely necessary to study and understand wave behavior.<br>Experiments<br>1. Simple Harmonic Motion of a Spring-Mass System can be studied to investigate the motion and properties of a spring-mass system undergoing simple harmonic motion and to verify the relationship among the variables<br>Demonstrations<br>1. A long coil of wire (Slinky toy) which can be stretched across the room can be used to demonstrate both longitudinal and transverse waves. Shaking the coil from side to side produces a transverse wave. Holding the spring taut and releasing a group of bunched-up coils produces longitudinal waves. Show that wave velocity is independent of how hard or frequently you shake the coil. A long helical spring, 2–3 cm in diameter and 6m long, will serve as well, and, together with the Slinky, illustrates effects of change in media. The coil |

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| resonance to occur in vibrating objects and in various media;<br><br>• Relate the energy of an oscillator to its amplitude<br>• Explain the energy changes that occur when a body performs simple harmonic motion<br>• Draw and interpret graphs showing time variation of kinetic energy and potential energy of an SHM<br>• Describe how to calculate period of a physical pendulum<br>• Solve problems on simple harmonic motion involving period of vibration and energy transfer<br>• Describe characteristics of mechanical waves<br>• Identify that the speed of mechanical waves depend on the nature of the media<br>• State the factors affecting the speed of a mechanical wave along a string<br>• Use the equation $v = \sqrt{T/\mu}$ to solve related problems<br>• State the factors affecting the speed of a mechanical wave along an elastic | **2.2. Wave Motion** *(4 periods)*<br>• Longitudinal and transverse waves<br>• Speed of a longitudinal wave | spring is easier to use to demonstrate the formation of standing waves.<br>2. A ripple tank is excellent in showing refraction, diffraction, and interference effects. A shallow dish on an overhead projector also works well.<br>3. A mechanical wave machine, if available, is very useful in demonstrating wave behavior.<br>Project Work(s)<br>4"Graph" simple harmonic motion by having student oscillate can of spray paint in unison with mass on spring ,following motion up and down as closely as possible .have two other students move 2-3 m length of paper horizontally at constant speed past spray paint nozzle moving in vertical plane. Result is large scale sine wave produced on a paper.<br>Alternately clamp meter stick to table and set in vibration –add pen at end to get displacement –time curve on card moved past pen at constant speed.<br>Given a graph of a simple harmonic motion function, you can ask students to calculate the phase constant.<br>5. Siren disk demonstrations: Rotate disk with variable speed rotator and use jet of air directed at holes. Different musical tones are heard from different circles of regularly spaced holes but noise is heard from circles of randomly spaced holes.Harmoic sounds are pleasing to ear. Place disk overhead for large class to observe spacing 6. Induced resonance in tuning fork: Let students in groups construct two wooden boxes, each with an open side .Fit identical tuning forks snugly into holes in the tops of the boxes and position the boxes opposite each other .strike one tuning fork and then slowly move the other box back and forth until it starts to hum "in sympathy" with the first. Does the induced tone have a higher, lower, or identical frequency to the inducing (original) tone? Is the amplitude of the induced sound greater, smaller or the same as the original? Students should give the correct answer from their observation. |

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| medium<br>• Describe characteristics of a traveling wave<br>• Derive the standard equation for a traveling wave<br>y = Acos(ωt + φ)<br>using the traveling wave equation<br>• Define the terms, phase speed, phase and phase constant for a traveling wave<br>• Use definition and equations for a traveling wave to solve related problems<br>• State the principle of superposition<br>• Illustrate graphically the principle of superposition<br>• explain and graphically illustrate the principle of superposition, and identify examples of constructive and destructive interference;<br>• Define standing waves as Oscillations with a stationary outline produced by the combination of two identical waves moving in opposite directions.<br>• identify the properties of | • Mathematical representation of a traveling wave<br>• Principle of superposition of Waves<br>**2.3 Sound, loundness and human ear** *(7 periods)*<br>• Reflection of waves<br>• Standing waves in strings and organ pipes | |

| ***Competencies*** | ***Contents*** | ***Suggested Activities*** |
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| standing waves and, for both mechanical and sound waves, explain the conditions required for standing waves to occur;<br>• Derive the standing wave equations $y_s = 2A\sin(kx)\cos(\omega t)$<br>• Define the terms: Nodes, Antinodes<br>• Use the equations $x=n\lambda/2$ and $x=(n+1/2)\lambda/2$ to find the positions of the nodes and antinodes on a standing waves<br>• analyze, in quantitative terms, the conditions needed for resonance in air columns, and explain how resonance is used in a variety of situations<br>• explain the modes of vibrations of strings and solve problems involving vibrating strings<br>• Use the equation $f_n = v/\lambda_n = nv/2l$ to find the frequency of the nth harmonics<br>• Use $f_n = nv/2l$ to find the nth harmonic in pipe open at both ends and $f_n = nv/4l$ to find the nth harmonic in pipe open with one end<br>• Explain the way air columns vibrate and | • Fundamental mode and harmonics, beats<br>• Musical instruments<br>• Pitch and frequency | |

| ***Competencies*** | ***Contents*** | ***Suggested Activities*** |
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| solve problems involving vibrating air column<br>• analyze resonance conditions in air columns in quantitative terms<br>• Identify musical instruments using air columns, and explain how different notes are produced<br>• Define intensity of sound<br>• State the relationship between intensity of sound and distance from the source<br>• Describe the dependence of speed of sound in a medium on the bulk modulus (B) and density ρ of the medium<br>• Use V= $\sqrt{B/\rho}$ to solve related problems and to compare speed of sound in different media<br>• Define the terms Threshold of pain and threshold of hearing<br>• Use the logarithmic relation to give intensity level of a sound in decibels<br>• Describe the intensity level versus frequency graph to know the frequency to which the | • Intensity of sound<br>• Intensity level<br>• Speed of sound in different media | |

| ***Competencies*** | ***Contents*** | ***Suggested Activities*** |
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| human ear is most sensitive<br>• explain the Doppler effect, and predict in qualitative terms the frequency change that will occur in a variety of conditions;<br>• Use the relation ship between original frequency (f) and new frequency (f') to solve related problems<br>• Explain some practical applications Doppler's effect and related phenomena | • Doppler Effect | |

## Assessment

The teacher should assess each students work continuously over the whole unit and compare it with the following description, based on the competencies, to determine whether the student has achieved the minimum required level.

**Students at minimum requirement level**

A student working at the minimum requirement level will be able to: define the terms periodic motion, simple harmonic motion, angular harmonic motion, resonance, fundamental modes ,harmonics and beats; state the necessary condition for the establishment of a standing wave, describe the conditions for simple harmonic motion to take place; distinguish among free, forced, and damped oscillations; identify points in simple harmonic motion where acceleration, kinetic energy and potential energy are maximum/minimum; derive the mathematical expression for a traveling wave ;describe Doppler's effect; solve problems involving periodic and wave motion; give simple examples of vibrating systems; explain the energy changes that occur when a body performs SHM; draw and interpret graphs showing time variation of KE and PE of an oscillator; solve problems on SHM involving periods of vibration and energy changes; explain the damped oscillations; identify the properties of standing waves for both mechanical and sound waves; explain the conditions required for standing waves to occur; explain the Doppler effect, and predict, in qualitative terms the frequency change that will occur in a variety of conditions; explain the modes of vibrations of strings and solve problems involving vibrating strings; Explain the way air columns vibrate; solve problems involving vibrating air column.

**Students above minimum requirement level**

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

**Students below minimum requirement level**

Students working below the minimum requirement level will require extra help if they are to catch up with rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

## Unit 3: Wave *optics* *(10 periods)*

**Unit *outcomes*:** Students will be able to:

- Recognize the limitations of geometric optics
- Define and explain units and concepts related to the wave nature of light
- Use laboratory materials in a prescribed manner when conducting lab investigations
- explain the behavior of light when light waves from coherent sources interact each other (interference)
- explain the behavior of light when it interacts with material obstacles (diffraction)
- deduce the wave nature of light
- explain experimental observations using the wave nature of light
- demonstrate an understanding of the wave model of electromagnetic radiation, and describe how it explains diffraction patterns, interference, and Huygens's principle
- perform experiments relating the wave model of light and technical applications of electromagnetic radiation to the phenomena of refraction, diffraction, interference.

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| *Students will be able to:*<br>• Define the term wave front<br>• State Huygens's principle<br>• Differentiate between reflection and refraction<br>• Draw diagrams to illustrate reflection of wave fronts<br>• Draw diagrams to illustrate refraction of wave fronts<br>• State the laws of reflection and refraction<br>• Describe phenomena of wave interference as it applies to light qualitatively using diagrams<br>• describe the phenomenon of wave | ***3. Wave optics***<br>**3.1. Wave fronts and Huygens's principle***(1 period)*<br><br>**3.2. reflection and refraction of plane wave fronts** *(1 period)*<br><br>**3.3. Proof of law of reflection and refraction using Huygens's principle** *(2 periods)*<br><br>**3.4. Interference** *(1 period)* | Students have studied ray model of light in lower grades. The importance of another model of light (wave model) can be emphasized by the use of scientific and technological applications of the wave nature of light such as polarization, Polaroid sunglasses, Rainbows, polished gemstones, Stage lighting, Television, Ultraviolet and ozone layer, medical and night vision applications of Infrared cameras, and the Greenhouse effect.<br>**Experiments**<br>1. Measurement of the wavelength of a monochromatic light<br>2. Measurement of the focal length of a concave mirror.<br>3. Verification of Snells law of refraction.<br>4. Using a spectrometer, measure the angle of the given prism and the angle of minimum deviation. Calculate the refractive index of the material<br>**Demonstrations**<br>1. Demonstration of polarisation using polaroids or other suitable method.<br>2. Use a prism to produce a spectrum from a white light. (Tell about Newton's original experiment in 1665-6). Use a photocell (light meter) to scan the different colors. Continue into the region beyond the red where nothing is visible. Tell students that it was the experimental discovery of a non-visible portion of the electromagnetic spectrum). It is the infrared portion of the spectrum that produces the feeling of warmth when it strikes our bodies.<br><br>**Waves from a point source**:<br>3. Place the water trough on the overhead projector, and fill it with about 2-3 cm of water. Use an eyedropper or syringe held about 5 cm above the surface of the water to drip drops in the center |

| ***Competencies*** | ***Contents*** | ***Suggested Activities*** |
|---|---|---|
| interference as it applies to light in qualitative and quantitative terms, using diagrams and sketches;<br>• state the conditions necessary for the interference of light to be shown<br>• explain the principle of Young's double slit experiment<br>• carry out calculations involving Young's double slit experiment<br><br>• Describe Young's double slit experiment<br>• Identify a double-slit interference pattern is caused by differences in path length traveled by light emanating from each slit<br>• compare destructive/constructive interference occurring in a string with light<br><br>• Identify constructive interference of lights wave accounts for the bright regions and destructive interference cause the dark regions<br>• Define interferometer as a device that uses interference of two | **3.5. Young's double slit experiment and expression for fringe width** *(2 periods)*<br><br>• Double–slit experiment : wave nature of light<br>• Double slit experiment: wavelength of light<br>• Expressions for two-slit interference ( bright and dark fringes)<br>• Interferometer<br>• Phase change in reflection<br><br>3.6 Thin –film interference (1 period*)* | of the trough at a steady rate, and watch the pattern on the wall or screen. Observe what happens with fewer d Waves from two point sources<br>4. Fill the two eye droppers with water, and hold them about a 3 cm apart and about 5 cm above the surface of the water in the trough. Squeeze the droppers so that drops fall from both at the same time at a fairly fast rate. Let students sketch the observed wave pattern<br>Let students in groups see an *interference pattern* created by causing a beam of light to pass through two parallel slits to illuminate a viewing screen.<br>In this section, the teacher needs to review some of the fundamentals of interference, and discuss the conditions necessary for light to make the interference pattern. .Students may have already studied the interference of mechanical waves; Some of the same principles and terminology are used in discussing both kinds of interference. Explain Young's double-slit experiment, his experimental apparatus used to calculate the wavelength of the light, clarify the analysis he employed in some detail.<br>Emphasize the important premise: There is a relationship between the locations of the bright fringes and wavelength. Next, use trigonometry to show how the wavelength of monochromatic light can be determined from quantities that Young could measure empirically.<br>Discuss the 2-slit bright and dark fringes equations. To explain this equation, consider the relationship between destructive interference, phase difference and path length.<br>**Homemade single slit:** The homemade single slit can be made by carefully cutting a slit with the razor blade and ruler into the metallic coating of the mirror. This produces a narrow slit that is quite adequate for these activities(diffraction and interference<br>rops per second and more drops per second. Let students sketch the observed wave pattern |

| ***Competencies*** | ***Contents*** | ***Suggested Activities*** |
|---|---|---|
| beams of light to make precise measurement of their path difference<br>• Identify light changes phase by $180^0$ when it reflects off a surface with higher refractive index than the medium it is traveling in<br>• Define thin-film interference as the interference caused by light waves reflecting off two different surface of a thin film<br>• Apply and use the thin film equations in the solution of problems<br>• Define diffraction as the expansion or spreading of wave front as it passes through an opening or a sharp edge<br>• Describe diffraction due to a single-slit<br>• Identify single-slit diffraction is caused by interference between light rays coming from different parts of the same slit<br>• identify the interference pattern produced by the diffraction of light through narrow slits (single and double slits | **3.7. Diffraction due to a single slit** *(2 periods)* | |

| ***Competencies*** | ***Contents*** | ***Suggested Activities*** |
|---|---|---|
| • Define diffraction grating as a material with a large number of narrow, regularly spaced slits or grooves designed to produce interference pattern<br><br>• describe and explain the phenomenon of wave diffraction as it applies to light in quantitative terms, using diagrams<br>• solve problems involving interference and diffraction of waves describe and explain the phenomenon of wave diffraction as it applies to light in quantitative terms, using diagrams<br>• solve problems involving interference and diffraction of waves<br>• | | |

## Assessment

The teacher should assess each students work continuously over the whole unit and compare it with the following description, based on the competencies, to determine whether the student has achieved the minimum required level.

**Students at minimum requirement level**
A student working at the minimum requirement level will be able to: define the terms wave front, reflection, refraction. interference, diffraction of wave fronts; state Huygens's principle ;prove the laws of reflection and refraction; describe Young's double slit experiment, diffraction due to a single slit; describe experiments by which interference and diffraction phenomenon may be demonstrated; Describe an experiment illustrating interference of waves; Draw diagrams to illustrate reflection and refraction of waves; Explain diffraction at a single slit; Explain beats; solve problems involving interference and diffraction of waves; state the conditions necessary for the interference of light to be shown; carry out calculations involving Young's double slit experiment.

**Students above minimum requirement level**
Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

**Students below minimum requirement level**
Students working below the minimum requirement level will require extra help if they are to catch up with rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

## Unit 4: Electrostatics *(14 periods)*

***Unit outcomes*:** Students will be able to:

- Know how to calculate the electric field resulting from a point charge.
- Understand static electric fields have as their source some arrangement of electric charges.
- Know how to apply the concepts of electrical potential energy to solve problems involving conservation of energy
- Acquire knowledge and understanding in electrostatic phenomenon.

| *Competencies* | *Contents* | *Suggested Activities* |
|---|---|---|
| *Students will be able to:*<br>• analyze in quantitative terms,, the electric field and the electric forces produced by a single point charge, two point charges, and two oppositely charged parallel plate<br>• Describe Milikan oil experiment<br>• Assess the trajectory followed by the charged particles in an electric field<br>• Define the term an electric dipole<br>• Define electric dipole moment<br>• Describe what happen to a dipole placed in an electric field<br>• Determine the electric field strength at a point due to a dipole<br>• Define electric flux<br>• Define Gaussian surface<br>• State Gauss Law<br>• hUse the definition and | **4. *Electrostatics***<br>**4.1. Electric charge and coulomb's law**<br>*(5 periods)*<br>• Electric field E<br>• Electric field of a point charge<br>• Electric field of continuous charge distribution<br>• A point charge in an electric field<br>• A Dipole in an electric field<br>• Electric flux<br>• Statement of Gauss Law and its application | Electrostatics is fundamental to any study of electrical phenomena. Although students have the qualitative aspects of static electricity in previous grades, the interpretation and quantitative material will be new in grade 12. Experiments and Demonstrations are extremely important due to the abstract nature of the discussions.<br><br>**Experiments**<br>1. Investigate charging and discharging of a capacitor<br>2. Investigation of #–E between parallel plates using a charged foil strip.<br>3. Electric field patterns Plotting equipotential lines on a sheet of conducting material. Flame probe investigation of potentials in a parallel plate capacitor and around a charged sphere.<br><br>**Demonstrations**<br>1. Van de Graaff generator can be used for many demonstrations in electrostatics. (charging, grounding, )<br>2. A computer simulation of Millikan oil drop experiment is a good example of the use of uniform electric fields produced by parallel plates. Note that the average charge of the electron had been known from electrochemistry, but Millikan showed that each electron has the same charge.<br>3. Demonstrate charge sharing, emphasizing on its application of energy minimization and describing the grounding process.<br>4. Charge a Leyden jar. Use rubber rod to lift out the inner conductor, and then touch the inner can with the outer can to put both at the same potential. Using the rod, reassemble the jar. Test to show it is onece again cahrged. This test shows the storage of electric energy in the molecules of the plastic insulator.<br>Take apart a commercial capacitor (can be obtained from thrown away electronic gadgets like radio receiver) to show its metal and plastic foils<br><br>To explain the nature of electric fields, first review the fundamentals of the electrostatic force and state. Coulomb's law. Explain how charges establish electric fields around themselves.. |

| ***Competencies*** | ***Contents*** | ***Suggested Activities*** |
|---|---|---|
| Gauss law to solve related problems<br>• describe and explain, in qualitative terms, the electric field that exists inside and on the surface of a charged conductor<br>• Define electric potential energy as potential energy determined by the configuration of charges<br><br>• apply quantitatively the concept of electric potential energy in a variety of contexts<br>• compare the characteristics of electric potential energy with those of gravitational potential energy;<br>• derive the relationship between electric field strength and potential<br>• use the formula for the electric potential at a point due to an isolated point charge<br>• Apply the concepts of electrical energy to solve problems involving conservation of energy. | **4.2. Electric Potential** *(5 periods)*<br>• Potential difference<br>• Electric potential due to a point charge<br>• Electric potential due to a dipole and system of charges<br>• Equipotential surfaces<br>• Electric potential of a system of two point charges in an electric field | Use electric field diagrams to illustrate the nature of an electric field. An electric field diagram consists of electric field lines. Remind students to remember: Even after they calculate the strength of the field, their task is not finished, because an electric field has both magnitude and direction. They must specify the field's direction. Start by calculating the field vector generated by each charge at the given point to calculate the overall field at a point. Then add the vectors together. The result is the net electric field at that point due to all the charges.<br>Discuss electric potential energy and electric potential. Understanding these topics will be crucial to students understanding of how electric circuits and components work<br>Explain how electric charges and fields can create electric potential energy, electric potential, and electric potential differences. Recalling the fundamentals of gravitational potential energy may help to understand electric potential energy because the two are analogous<br><br>• |
| • Derive the formula for the capacitance of an parallel plate capacitor in terms of its geometry<br>• Use gauss' law to derive | **4.3. Capacitors and dielectrics** *(4 periods)*<br>• Parallel – plate capacitors and dielectrics | **Project Work(s)**<br>1. Study and report an industrial process which uses electrostatics. Note that the Principles and laws studied in electrostatic are applicable in textile, cement and printing industries.<br>Appropriate homework and example problems given by the teacher need to |

| ***Competencies*** | ***Contents*** | ***Suggested Activities*** |
|---|---|---|
| the formula for the capacitance of a parallel plate capacitor<br>• Explain the behavior of an insulator in an electric field<br>• Give definition of dielectric constant<br>• Define dielectric strength<br>• Derive an expression for capacitance of a parallel plate capacitor with dielectric<br>• Define electric energy density as the amount of electric potential energy in an electric field per unit volume<br>• Derive the formula for the energy density of an electric field using a parallel plate capacitor as the source of the field<br>• Solve problems involving capacitances, dielectrics, energy stored in a capacitor<br>• Explain qualitatively the charge and discharge of a capacitor in series with a resistor | • Effect of a dielectric<br>• Molecular theory of induced charges<br>• Charging and discharging of a capacitor | • Balance qualitative and quantitative reasoning<br>• Emphasizing reasoning ,de-emphasize formulas and equations<br>• Deal directly with phenomena and observations<br>The problems should focus students' attention on interpretation, on analysis, on reasoning-that is on doing physics. |

## Assessment

The teacher should assess each students work continuously over the whole unit and compare it with the following description, based on the competencies, to determine whether the student has achieved the minimum required level.

**Students at minimum requirement level**

A student working at the minimum requirement level will be able to: define the terms electric field ,electric dipole ,electric flux ,electric potential, equipotential surfaces, capacitors, capacitance, dielectric; explain the molecular theory of induced charges, the effect of inserting dielectric in the gap between the plates of capacitors; sketch the electric field lines, equipotential lines for an isolated point charges and a dipole; solve problems involving Coulomb's law ,electric field ,electric potential and capacitance; explain coulomb's law using the ideas of vectors; map an electric field lines pattern using electric lines of force; solve problems related to the capacitances of parallel plate capacitors; state Gauss law qualitatively; compare the characteristics of electric potential energy with those of gravitational potential energy; explain the electric field and the electric forces produced by a single point charge, two point charges, and two oppositely charged parallel plate; describe and explain, in qualitative terms, the electric field that exists inside and on the surface of a charged conductor; apply the formula the electric field strength at a point due to an isolated point charge; use the formula for the electric potential at a point due to an isolated charge.

**Students above minimum requirement level**

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

**Students below minimum requirement level**

Students working below the minimum requirement level will require extra help if they are to catch up with rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

## Unit 5: Steady electric current and circuit properties *(13 periods)*

***Unit outcomes*:** Students will be able to:

- demonstrate an understanding of the components and functions of electrical circuits that are commonly found at home and in the workplace
- construct, analyze, simple electrical circuits, using schematic diagrams, working with electrical tools and components, and examining small everyday electrical devices and appliances
- investigate how electrical devices play a role in the economy of the local community and in the improvement of our standard of living.

| *Competencies* | *Contents* | *Suggested Activities* |
|---|---|---|
| *Students will be able to:*<br>• Define the terms: terms: resistance, resistivity, conductivity, current density, drift velocity<br>• Define the units: coulomb, volt, ohm, watt, joule<br>• Identify current density is a vector quantity<br>• Express drift velocity in terms of current density, number of charge carriers per unit volume and elementary charge<br>• Express the relation between emf, terminal p.d and internal resistance<br>• analyze, in quantitative terms, circuit problems involving potential difference, current, and resistance<br>• Explain how the sources of emf produce a p.d.<br>• Compute the p.d across a resistor in a circuit<br>• State Kirchhoff's | ***5. Steady electric current and circuit properties***<br>*(13 periods)*<br>• Electric current<br>• Current density (drift velocity, mobility)<br>• Resistance, Resistively and conductivity<br>• Emf and internal resistance of a battery<br>• Energy and electric potential in a circuit<br>• Kirchhoff's Laws and simple calculations | Discussions and demonstrations in this unit can be enriched using a lot of everyday examples like magnetic and chemical effects. Experiments recommended in this unit can be performed by the students themselves.<br>**Experiments**<br>1. I-V characteristics (Ohm's law) for a given unknown resistance (eg. 100cm constantant wire), plotting a graph of pd versus current. From the slope of the graph and the length of the wire, calculate the resistance per cm of the wire.<br>2. Verification of the laws of combination of resistance<br>3. Determination of internal resistance of a cell using potentiometer<br>4. Finding an unknown resistance by the use of Wheatstone's bridge and determination of the specific resistance of a wire.<br>**Demonstrations**<br>1. Compare the emf of two cells using a potentiometer<br>2. Variation in potential drop with length of slide wire for constant current, hence to determine specific resistance<br>3. Determine the internal resistance of a cell by potentiometer device.<br>Explain Kirchhoff's two powerful rules that aid in the analysis of circuits. First discuss his loop rule. Show how to apply Kirchhoff's loop rule to some more complicated circuits.<br>Clarify Kirchhoff's junction rule by stating it in simple words as current in equals current out. Highlight Kirchhoff's rule is an implication of the principle of conservation of charge, which states that charge is neither created nor destroyed. The amount of charge flowing in equals the amount of charge flowing out.<br>The last section on measuring instruments is to train students in using Galvanometer, Ammeter, and voltmeter. Conversion of galvanometer to Ammeter and Voltmeter can be practiced by the students. Commercial millimeters can also employed in experiments.<br>Demonstration: Resistance Analog.<br>Ball bearings,1/4"(0.6cm)diameter or less, moving through maze of nails simulate current flow in wire. Nail spacing and ball size determine mean free path. Use different number balls to show change in number of charge carriers. Inclined board at different angles to show effect of different applied EMFs(drift velocities) |

| ***Competencies*** | ***Contents*** | ***Suggested Activities*** |
| --- | --- | --- |
| Junction rule<br>• State kirchhoff's loop rule<br>• Identify that kickoff's junction rule is a consequence of law of conservation of charge<br>• Identify that the loop rule is a consequence of conservation of energy<br>• Use kirchhoff's rules to solve related circuit problems<br>• Identify the sign conventions appropriately in applying Kirchhoff's rules<br>• solve problems involving network resistors<br>• Describe how shunt resistors are used to measure a wide range of currents and p,d<br>• Calculate shunt and multiplier value for use with a meter to give different current and voltage ranges<br>• solve problems in which meter resistance is involved<br>• describe how a galvanometer can be modified to measure a wide range of currents and potential differences<br>• calculate shunt and multiplier value for use | • Measuring instruments<br>• Shunt resistors<br>• The measurement of resistance : Wheatstone bridge | Demonstration;<br>1. Solve simple circuit, then show by measuring currents and voltages with digital meters that theoretical value are confirmed. Discuss errors in measurement and meter errors and their propagation through calculation<br>2. Given circuit diagram, let students rank the bulbs in the circuit according to brightness when the switch is open, when the switch is closed. They should also explain their reasoning.<br>3. Let students' state whether the bulbs in the given circuits are arranged in series, parallel, or neither, for each possible combination of switch positions.<br>The learning difficulties revealed in teaching and learning electricity have to be adequately addressed. There appear to be two key concerns:<br>(1) Current flow and energy flow have to be clearly differentiated<br>(2) Current and voltage have to be differentiated.<br><br>**Project Work(s)**<br>1. Conversion of Galvanometer to an Ammeter and Voltmeter<br>2. ***Saving on your electric bill*** fluorescent bulbs deliver the same amount of light using much less power. If one kW-hr costs 10¢ ,assist students to estimate the amount of money they would save each month by replacing all the 75 W incandescent bulbs in their house by 15 W fluorescent ones. |

| ***Competencies*** | ***Contents*** | ***Suggested Activities*** |
|---|---|---|
| with a meter to give different current and voltage ranges<br>• identify and appropriately use equipment for measuring potential difference, electrical current, and resistance (e.g., use multimeters and a galvanometer to make various measurements in an electrical circuit;<br>• use an oscilloscope to show the characteristics of the electrical current);<br>• explain the principle of Wheatstone bridge solve problems involving it<br>• explain the principle of potentiometer and how it can be used for measurement of emf,p.d, resistance and current<br>• solve problems involving potentiometer circuits | • Potentiometer and its uses<br>• Potential dividers | |

## Assessment

The teacher should assess each students work continuously over the whole unit and compare it with the following description, based on the competencies, to determine whether the student has achieved the minimum required level.

**Students at minimum requirement level**

A student working at the minimum requirement level will be able to: define the terms electric current, current density, resistance ,conductivity, resistivity ,drift velocity mobility; describe the principles of potentiometer, wheatestone bridge; describe how to convert a galvanometer to a voltmeter and an ammeter; Explain the meaning of a coulomb, a volt, an ohm, potential difference, resistance, emf, KWH; identify the SI units of electric current, current density, resistance, resistivity, conductivity, temperature coefficient of resistance; distinguish between electrostatic and non electrostatic fields; differentiate between emf and p.d of a source; solve electrical circuit problems involving the relationship between emf, current and resistance for a complete circuit; Distinguish between emf and p.d, ohmic (linear)and non ohmic (non linear) devices; state and apply kirchhoff's laws; solve problems involving network resistors; solve problems in which meter resistance is involved; describe how a galvanometer can be modified to measure a wide range of currents and potential differences; use the formula for the electric potential at a point due to an isolated charge; calculate shunt and multiplier value for use with a meter to give different current and voltage ranges; explain the principle of Wheatstone bridge solve problems involving it; explain the principle of potentiometer and how it can be used for measurement of emf, p.d, resistance and current.

**Students above minimum requirement level**

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

**Students below minimum requirement level**

Students working below the minimum requirement level will require extra help if they are to catch up with rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

## Unit 6: Magnetism *(12 periods)*

***Unit outcomes***: Students will be able to:

- demonstrate an understanding of the concepts, principles, and laws related to electric, and magnetic forces and fields, and explain them in qualitative and quantitative terms
- conduct investigations and analyze and solve problems related to electric, and magnetic field;
- explain the roles of evidence and theories in the development of scientific knowledge related to electric, and magnetic fields, and evaluate and describe the social and economic impact of technological developments related to the concept of magnetism
- determine the magnitude of the force on a moving particle (with charge q) in a magnetic field is qvB sin(a), where a is the angle between **v** and **B** (v and B are the magnitudes of vectors **v** and **B,** respectively
- identify and describe examples of domestic and industrial technologies that were developed on the basis of the scientific understanding of magnetic fields.

| ***Competencies*** | ***Contents*** | ***Suggested Activities*** |
|---|---|---|
| *Students will be able to:*<br>• Describe magnetic properties of matter.<br>• distinguish between the terms: dia, para and Ferro magnetic materials<br><br>• Define magnetic field<br>• State the properties of magnetic field lines.<br><br>• describe the properties, including the three-dimensional nature, of magnetic fields<br>• Describe the motion of a charged particle in a magnetic field<br>• Identity a moving charge set up magnetic field<br>• Use the equation F= qvXB to determine the magnitude and direction of the force<br>• use the expression for the | ***6. Magnetism***<br>**6.1 Concepts of magnetic field** *(1 period)*<br>• Magnetic field lines<br>• Magnetic flux<br><br>**6.2 Magnetic materials (dia, para, ferro***(1 periods)*<br><br>**6.3 Motion of charged particles in magnetic field** *(2 periods)* | **Experiments**<br>1. The variation of magnetic field, due to a current carrying conductor, with distance and current can be investigated with a variable direct current source and a compass needle. The deflection, away from the N-S direction of a compass needle is proportional to the magnetic field strength of the current carrying wire.<br>2. The combined magnetic field of the earth and a bar magnet placed with its north pole pointing geographic south can be plotted. Students can be asked to determine neutral points.<br>Describe the images on the screens of traditional televisions and computers are the result of electrons being accelerated by an electric field, subsequently being "steered" by magnetic fields, and then striking the screen to create light of different colors at specific locations.<br>Stress on the four factors that determine the amount of force exerted by a magnetic field on a moving particle. They are the particle's charge and speed, the strength of the magnetic field and the angle of intersection between the particle's velocity and the magnetic field. The force is greatest when these two vectors are perpendicular, and zero when they are parallel.<br>3. Hang current bearing wire in field of strong magnet to show the effect of transverse force. Connect flexible wire and switch to lab supply capable of up to 5A.Arrange wire to hang loosely in field and briefly close and open circuit .If magnet is weak ,place iron "keeper" across poles to increase B.Reverse magnet and/or battery connection to show effect of direction .discuss F=qvBsin θ<br>4. Place coil (armature) with ends through looped wires at ends of battery .Place button or rectangular magnet on top of battery beneath artmature.It may be necessary to give armature initial motion to start and adjustment of end loops may be necessary to keep coil from hitting magnet. Coil ends should be aligned so coil balances well in end loops.(Do not leave connected long because current drain is large) |

| ***Competencies*** | ***Contents*** | ***Suggested Activities*** |
| --- | --- | --- |
| force on a charged particle in a magnetic field<br>•<br>• solve problems on the motion of charged particles in electric and magnetic fields<br>•<br>• Describe the path if $\theta \neq 90^0$<br>• Describe Thomson's experiment of charge to mass ration<br>• Determine the value of e/m ration for this specific experiment<br><br>• analyze and predict, by applying the right-hand rule, the direction of the magnetic field produced when electric current flows through a long straight conductor and through a solenoid<br>• use the expression for the force on a current carrying conductor in a magnetic field<br>▪ Derive the expression $F = I(l \times B)$<br>▪ Calculate the magnetic field strength of a straight current carrying wire<br>• describe and illustrate the magnetic field produced by an electric current in a | • Thomson's measurement of e/m<br><br>**6.4 Magnetic force on current carrying conductors (long straight, circular loop)***(3 periods)* | Project Work (s)<br>5. Magnetic field of a current carrying wire: Use a ring stand and clamp to hold a piece of cardboard horizontally .Thread connecting wire through a hole in the cardboard, then connect the wire to a battery and switch. Place several small compasses on the cardboard around the wire. Draw a sketch to show how the compasses are oriented before the switch is closed. Hold the wire vertically .Close the switch briefly and observe the behavior of the compass needles. Make a sketch that shows magnetic field lines near the current –carrying wire Discuss:<br>• How you decided to draw the lines as you did<br>• How the field lines that you drew differ from those of a bar magnet<br>• How you took into account the magnetic field of the earth<br>6. Making magnets with a current carrying wire: Wrap a 20 cm piece of insulated wire around a pencil several times. Remove the pencil and place the wire coil on the previous cardboard. Connect the coil to a fresh battery through two holes in the cardboard and place several compasses around the coil .Before you close the switch, sketch the coil and compasses in your note book Close the switch and observe the orientations of the compass needles. Examine how the magnetic field is affected when the shape of the wire is changed.<br>**Demonstrations**<br>1. Force on a conductor and coil in a magnetic field.<br><br>**Project Work(s)**<br>1. Investigate the effect on the force of attraction between a solenoid and bar magnet under different strength of current and when the current through the solenoid is changed<br>2. Determination of the horizontal component of the Earth's magnetic field Explain to students that Magnetic fields exert forces on moving, electrically charged particles. This phenomenon makes for a good demonstration in a physics class. |

| ***Competencies*** | ***Contents*** | ***Suggested Activities*** |
|---|---|---|
| long straight conductor and in a solenoid<br>▪ Determine the magnitude and direction of torque acting on a current loop<br>▪ Define magnetic dipole moment<br>• Describe the working mechanism of a direct motor<br>▪ State Biot -savart law<br>• Apply and use Biot-Savart law to determine the expression for magnetic field strength of a current element<br>• state Ampere's law and use it in solving problems<br>• describe the causes of earth's magnetism<br>• Determine the horizontal component of Earth's magnetic field at a location | • Torque on a current loop<br>• Magnetic dipole moment<br>• Dc Motor<br><br>**6.5. Ampere's law and its application** *(2 periods)*<br><br>**6.6. Magnetic field due to a current element** *(1 period)*<br><br>**6.7. Earth's magnetism** *(2 periods)*<br><br>• Causes<br>• Horizontal & vertical components<br>• Tangent galvanometer | |

## Assessment

The teacher should assess each students work continuously over the whole unit and compare it with the following description, based on the competencies, to determine whether the student has achieved the minimum required level.

**Students at minimum requirement level**

A student working at the minimum requirement level will be able to: define the terms magnetic field, magnetic field lines, magnetic field strength , magnetic flux para-magnetic, dia-magnetic, and ferro-magnetic materials; describe the motion of a charged particle in a magnetic field; describes Thomson's experiment of charge to mass ratio; state Ampere's law, cause of earth's magnetic field; apply Ampere's law to solve problems; calculate the magnetic field strength of a straight current carrying wire, a solenoid ,circular loop; describe and illustrate the magnetic field produced by an electric current in a long straight conductor and in a solenoid **;p**redict by applying the right-hand rule, the direction of the magnetic field produced when electric current flows through a long straight conductor and through a solenoid; use the expression for the force on a current carrying conductor in a magnetic field; use the expression for the force on a charged particle in a magnetic field; state Ampere's law and use it in solving problems; solve problems on the motion of charged particles in electric and magnetic fields; distinguish between the terms: dia, para, and Ferro magnetic materials; describe the causes of earth's magnetism; describe an experiment to obtain the flux pattern around a bar magnet, straight carrying wire, a solenoid carrying a current.

**Students above minimum requirement level**

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

**Students below minimum requirement level**

Students working below the minimum requirement level will require extra help if they are to catch up with rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

## Unit 7: Electromagnetic induction and AC circuits *(18 periods)*

***Unit outcomes*: Students will be able to:**

- Understand the relationship between the current and the magnetic field, faraday's law ,Lenz's law, electromagnetic induction, motional electromagnetic induction, magnetic flux,
- Acquire knowledge and understanding in ac current, emf, generator, ac capacitor circuit, ac inductor circuit,
- Know changing magnetic fields produce electric fields, thereby inducing currents in nearby conductors
- Carry out experiments to demonstrate faraday's law
- Understand the behavior of simple circuits containing resistors, inductors and capacitors.

| *Competencies* | *Contents* | *Suggested Activities* |
|---|---|---|
| *Students will be able to:*<br>• Define magnetic flux<br>• Use $\Phi_B = B \cdot A$ $\Phi_B = BA \cos\theta$ to solve related problems<br>• Use the terms: induced emf, back emf, magnetic flux, flux linkage, eddy current<br>• Describe experiments to investigate the factors which determine the direction and magnitude of an induced emf<br>• State the laws of electromagnetic induction<br>• Use the laws of electromagnetic induction which predict the magnitude and direction of the induced emf<br>• Use $\varepsilon = -N\Delta\Phi / \Delta t$ to solve related | ***7. Electromagnetic induction and ac circuits***<br>**7.1. Phenomena of electromagnetic induction** *(6 periods)*<br>• Magnetic flux<br>• Faraday's law: induced emf and current | **Experiments**<br>1. Variation of voltage and current in a.c. circuits consisting of only resistors, only inductors and only capacitors (phasor representation), phase lag and phase lead. Can be seen using oscilloscope and signal generator.<br>2. To investigate how the number of turns (n), the diameter of the coil (d), the frequency (f), and the magnetic field strength (B) are related to the induced voltage (V) students can use secondary coils (solenoids) of different number of turns and diameters inserted into a primary coil (solenoid) of greatest diameter carrying a variable ac current. The frequency of the current in the primary coil can be changed using a signal generator and the induced voltage can be obtained from a reading on oscilloscope<br>**Demonstrations**<br>1. The principle and laws of electromagnetic induction<br>2. Use oscilloscope to show variation of voltage and current with time, i.e. alternating voltages and currents.<br>3. The effect of capacitor and resistor, on the time constant of RC circuit, can be studied by observing discharging of a capacitor with time. i.e. voltage across a discharging capacitor is measured as a function of time for a discharging capacitor connected to resistor. The time constant, which is a function of the resistance and capacitance in the circuit, will be determined from this data, which provides the information necessary to compute the capacitance.<br>4. Levitate small magnet over spinning disk. Affix very strong, light-weight, ceramic ring |

| *Competencies* | *Contents* | *Suggested Activities* |
|---|---|---|
| problems<br>• analyze and describe electromagnetic induction in qualitative terms<br>• apply Lenz's law to explain, predict, and illustrate the direction of the electric current induced by a changing magnetic field, using the right-hand rule<br>• Describe the effects of eddy currant in large piece of conducting materials<br>• Use an expression for the induced emf in a conductor moving through a uniform magnetic field by considering the forces on the charges<br>• Solve problems involving calculations of the induced emf,indued current<br>• define the terms: self inductance L,mutual inductance M, and henry, H<br>• state the factors which determine the magnitude of self inductance and mutual inductance<br>• Use an expression for the energy stored by an inductor through which a | • Lenz's law , eddy current<br><br>• Motional emf<br><br>• Self and mutual inductance | magnet to narrow strip of manila folder using double –sided tape. Magnet will levitate about 1cm above spinning aluminum disk when held near periphery. Show that levitation height depends on linear speed of disk by guiding magnet toward axis of rotation. Convince students that air currents are not responsible by using duplicate piece of card without magnet.<br><br>5. LR circuit: Use large inductor in series with high power bulb (200w).Place low power bulb (15W) in parallel with inductor .Apply 120 VDC with switch. Closing switch first light 15W bulb due to large back emf in inductor .As steady state is reached ,200W bulb serves as detector of increased current .Opening switch produces momentary flash of 15 W bulb from back emf due to suddenly decaying current<br><br>6. Building motors: Wind a long piece of sturdy insulated wire around a soft drink can several times and then remove the can so that you have a wire coil with several loops. Wrap the ends of the wire around the loops so that they do not separate. Leave enough wire at the ends of the coil to be able to bend them into support leads. Remove the insulating material from the leads of the coil. Obtain a metal wire cloth hanger and cut it to form conducting supports for the coil .Stand the supports upright by fitting the ends into holes in the wooden board. Predict how the coil will behave when the north pole of a bar magnet is placed near the coil and the switch is closed. Use a strong magnet to check your prediction. By using stronger magnets or larger currents, it is possible to make motors that can drive machines and perform various tasks. In some motors, the coils are held stationary and the magnets spin. If some electric motors are available in your classroom, examine them and see if you can recognize the parts that correspond to the parts of your motor.<br><br>**Project Work(s)**<br>Assign students to investigate and report on<br>• Dimmer switches in stage lighting uses of inductors.<br>• Uses of transformers.<br>• National grid set by Ethiopian Electric Power Corporation (EEPCo )and a.c |

| ***Competencies*** | ***Contents*** | ***Suggested Activities*** |
|---|---|---|
| current is passing<br>• Derive an expression of inductance of a solenoid($L = n^2 s\mu_0 A$ )<br>• Derive an expression for the energy stored in an inductor($PE_B = ½LI^2$)<br>• Define magnetic energy density<br>• compare direct current (DC) and alternating current (AC) in qualitative terms<br>• Derive the expression for the emf induced in a rotating coil $\varepsilon = \omega NBA \sin \omega t$<br>• Draw a schematic diagram for a simple A-C generator<br>• Explain the working mechanism of a generator<br>• Draw a schematic diagram of a transformers<br>• explain the importance of alternating current in the transmission of electrical energy<br>• Derive transformer equation $V_1/V_2=N_1/N_2=I_2/I_1$ from Faraday's law<br>• Identify that the current and voltage are in phase in a resistor in AC circuit | **7.2 AC generator & Transformers**<br>*(1 period)*<br>• The emf induced in a coil rotating in a magnetic field A-C<br>• Generator | |

| ***Competencies*** | ***Contents*** | ***Suggested Activities*** |
|---|---|---|
| • Identify that the current leads the voltage by $\Pi / 2$ in a capacitor in AC circuit<br>• explain the behavior of a capacitor in an a.c circuit<br>• Draw phasor diagram for a resistive and capacitive circuits<br>• Derive the expression for the instantaneous current and voltage in a resistive and capacitive circuit<br>• Define capacitive reactance<br>• Identify that voltage leads the current by Π/2 in an inductive circuit<br>• explain the behavior of an inductor in an a.c circuit<br>• Derive the expression for the instantaneous current/voltage in an inductor in a inductive circuit<br>• Define inductive reactance<br>• Describe the behavior of RL circuit<br>• Describe the behavior of LC circuit<br>• Describe the behavior of RLC circuits<br>• Derive an expression for the impedance of RLC circuits | **7.3 A C current**<br>*(4 periods)*<br>• AC and resistor<br>• AC and capacitor<br>• R L and R C circuits<br>• , Resonance<br>•<br>• AC and inductor<br>• RC Circuit<br>• Reactance and impedance<br>• RL circuit | |

| Competencies | Contents | Suggested Activities |
|---|---|---|
| • Draw phasor diagrams for RLC circuit<br>• Solve problems involving the magnitude and phase of current and applied p.d in an a.c circuits which include resistors, capacitors and inductors<br>• explain what are meant by r.m.s. values<br>• Define power factor in an AC circuit<br>• Use the terms:r. m.s. current, r, m, s, potential difference, peak current, peak potential difference, half cycle average current, phase difference, phase lag, phase lead<br>• Apply the relationship between r.m.s. and peak values for the current and potential difference for a sinusoidal waveform<br>• Use the terms: reactance, impedance, power factor with their correct scientific meaning<br>• Show the average power in AC capacitive circuit is Zero<br>• Derive the expression for the average power in AC inductive circuit<br>• Derive the expression for the average power in AC R-L-C circuit | • L C oscillations (qualitative treatment)<br>• RLC series circuit<br><br>**7.4 Power in A C circuit** *(7 periods)*<br><br>• Peak values<br>• Power in AC capacitive circuit<br>• Power in AC inductive circuit<br>• Power in AC RLC circuit | |

| ***Competencies*** | ***Contents*** | ***Suggested Activities*** |
|---|---|---|
| • Distinguish between real, apparent and ideal power of an R-L-C | | |

## Assessment

The teacher should assess each students work continuously over the whole unit and compare it with the following description, based on the competencies, to determine whether the student has achieved the minimum required level.

**Students at minimum requirement level**

A student working at the minimum requirement level will be able to: Use the terms: induced emf, back emf, magnetic flux, flux linkage, eddy current; State the laws of electromagnetic induction; predict the magnitude and direction of the induced emf using the laws of electromagnetic induction; Use the expression for the force on a current carrying conductor in a magnetic field; Use the force on a charged particle in a magnetic field; Use the flux density near a long straight wire, at the centre of circular coil, inside and at the end of a long solenoid; Solve problems on the motion of charged particles in electric and magnetic fields; Describe in words, or by sketch, the general shape and relative intensities of magnetic field strength around a long straight current carrying wire,a long solenoid; apply Lenz's law to explain, predict, and illustrate the direction of the electric current induced by a changing magnetic field, using the right-hand rule; explain Ampere's law; Use an expression for the induced emf in a conductor moving through a uniform magnetic field by considering the forces on the charges; Solve problems involving calculations of the induced emf, indued current; compare direct current (DC) and alternating current (AC) in qualitative terms; define the terms: self inductance L, mutual inductance M, and Henry; Use the terms: r.m.s. current, r.m.s. potential difference, peak current, peak potential difference, half cycle average current, phase difference, phase lag, phase lead; Apply the relationship between r.m.s.and peak values for the current and potential difference for a sinusoidal waveform; Use the terms: reactance, impedance, power factor with their correct scientific meaning; Solve problems involving the magnitude and phase of current and applied p.d in an a.c circuits which include resistors, capacitors and inductors; Draw phasor diagrams for R, L and C circuits;**-** explain the behavior of a capacitor and inductor in an a.c circuit.

**Students above minimum requirement level**

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

**Students below minimum requirement level**

Students working below the minimum requirement level will require extra help if they are to catch up with rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

## Unit 8: Atomic physics *(20 periods)*

***Unit outcomes:*** Students will be able to:

- Acquire knowledge and understandings in the nature of matter and radiation, structure of atoms and nuclei,
- Develop skills in applying the law of radioactive decay ;describing some uses of radioactivity and safety precautions
- Discuss the action of nuclear reactor
- Describe how the introduction of new conceptual models and theories can influence and change scientific thought and lead to the development of new technologies.
- outline the historical development of scientific views and models of matter and energy, from Bohr's model of the hydrogen atom to present-day theories of atomic structure construct a concept map of scientific ideas that have been developed since Bohr's model.

| *Competencies* | *Content* | *Suggested Activities* |
|---|---|---|
| *Students will be able to:*<br>• Identify that black body absorbs all electromagnetic radiation<br>• describe the photoelectric effect and its characteristics<br>• apply quantitatively the laws of conservation of mass and energy, using Einstein's mass-energy equivalence<br>• Show understanding that matter has wave nature<br>• Use the De-broglie equation $\lambda = h / p$ to find the wavelength of a matter particle<br>• State Heisenberg's uncertainty principle<br>• Use uncertainty principle to relate the uncertainties in position and momentum<br>• Find the uncertainty in position from the uncertainty in momentum<br>• Describe Rutherford's model of atom<br>• Describe Bohr model of atom<br>• Show understanding that electrons can only exist at specific energy states, and | **8 *Atomic physics***<br>**8.1 Dual nature of matter and radiation** *(8 periods)*<br>• Blackbody radiation<br><br>**8.1.1. Photo electric effect**<br>• Einstein's photo electric equation (particle nature of light)<br>• Matter waves- wave nature of particle<br>• De-Broglie relation<br><br>• Uncertainty principle<br><br>**8.2 Atoms and Nuclei** | In this unit the work of Rutherford and Bohr that determined the model of the atom are being explained and use of these models to explain phenomena like laser light and photoelectric effect are presented.<br>Demonstrations depend primarily on the equipment and radioactive sources available.<br>The teacher should not allow students to do experiments by themselves.<br>It might be possible to contact a local hospital regarding the use of nuclear medicine for analysis or treatment. If a tour cannot be arranged, perhaps a specialist can speak to the class. Similarly<br>**Experiments**<br>1. Half-life simulation can be performed using free applets available from the internet<br>2. Simulation of Nuclear Collisions can be observed using free applets available from the internet<br>**Demonstrations**<br>1. Use either a prism or diffraction grating spectrometer to show the difference between continuous or line spectra. A simple absorption spectrum can be shown by crushing leaves in alcohol. The chlorophyll solution will absorb at both ends of the spectrum<br>2. If geiger counter is available decay of radioactive materials can be detected. Some counters can separate betas from gammas by absorbing the betas in a metallic cover. Few have windows thin enough to detect alphas. If you can detect betas and gammas, use aluminum sheets and lead sheets to show that betas are stopped by aluminum but lead is required to stop gammas<br><br>To explain why some atoms are stable and others are not, it helps to consider a |

| ***Competencies*** | ***Content*** | ***Suggested Activities*** |
| --- | --- | --- |
| will not be found with energies between those levels<br>• Compute the change in energy of atom using the relation $\Delta E = E_f - E_i$<br>• State the approximate size of an atom<br>• Compares the charge and mass of the electron with the charge and mass of the proton.<br>• Represent diagrammatically the structure of simple atoms.<br>• Use the relationship A= Z+N to explain what is meant by the term isotopes<br>• Describe the need for safety measures in handling and using radio – isotopes<br>• Show understanding that radioactivity emission occur randomly over space<br>• Distinguish between the three kinds of emissions in terms of their nature, relative ionizing effect, relative penetrating power<br>• Name the common detectors for $\alpha - particle, \beta - particle, \gamma - rays$<br>• Identify the nature of the three types of emissions from radioactive substances<br>• Describe experiments to compare the range of alpha, beta and gamma in various media<br>• Predict the effect of magnetic and electric fields on the motion of alpha and beta particles and gamma rays<br>• Associate radioactivity with nuclear instability<br>• Represent and interpret nuclear | *(12 periods)*<br>• Rutherford model of atom<br>• Bohr model and energy levels<br>• Composition and size of nucleus<br>• Atomic masses, isotopes and isobars<br><br>• Alpha- particle scattering experiment (in relation to its relevance to the development of atomic theory)<br>• Radioactivity (alpha, betha, gamma particles and their properties)<br>• Radioactive decay law | diagram of stable and unstable nuclides where *Z* is plotted against *N*.Let students observe some important features of this diagram.<br><br>3. Discharge flame and radioactivity: Hold a candle flame near a charged electroscope and it discharges leaves. Flame produces ionization of nearby air. Repeat demonstration with opposite charge on electroscope. Holding weak radioactive source near electroscope may also cause discharge.<br>4. Simulate nuclear reactions produced by high speed particles by using marbles accelerated down sloping aluminum channel into saucer .Those in saucer are analogous to target nuclei .Include several ball bearings of differing sizes. Show effect of speed by launching from different height and angles and effect of mass and increased momentum of projectiles by using different ball bearings. Ball with sufficient momentum can cause ejection of one or more marbles from saucer. Discuss analogy to bombarding nuclei with particles of ever increasing mass-proton, deuteron, and alpha.<br>5 Chain reaction Analog: Spring- loaded mouse trap set with small silicone ball (super ball) simulates fissionable nuclide. Assemble 30-50 of these and place inside acrylic enclosure. ”Trigger” neutron (another silicone ball) dropped through hole in center of enclosure initiates “chain reaction .Some “nuclide” usually remains unaffected. Ping pong balls are not as effective as heavier silicone balls. Beware-spontaneous fissions can occur during set up of 30-50 traps! Construct acrylic enclosure about 60x60x 25cm high.<br>Project Work (s)<br><br>***Waves and particles***<br>Form a group in a class and let students discuss the wave and particle character of photons and electrons. Discuss an experiment in which a photon behaves like a particle and an experiment in which it behaves like a wave.<br><br>**Project Work(s)**<br>Students can be assigned to investigate and report<br>1. The fraction of energy generated from nuclear power in Africa and the rest of the world<br>2. Peaceful uses of Nuclear Radiation in Ethiopia and Africa<br>3. Nuclear Facilities in Africa |

| ***Competencies*** | ***Content*** | ***Suggested Activities*** |
|---|---|---|
| reactions of the form $^{14}_{6}C \longrightarrow {}^{14}_{6}N + {}^{0}_{-1}e$ ( beta particle)<br>• State the uses of radio active isotopes<br>• Define the term,' half life'<br>• Identify that the decay process is independent of conditions outside the nucleus'<br>• Work through simple problems on half –life<br>• Use graphs of random decay to show that such processes have a constant half- life<br>• Describe problems posed by radioactive waste<br><br>• Identify nuclear force is a very strong force that holds particles in a nucleus together<br>• State some important properties of the strong force<br>• State nuclear properties<br>• Explain how stability is determined by binding energy per nucleon<br>• Show radius and mass number are related mathematically.<br>• $R= (1.2x10^{-15} m) A^{1/3}$<br>• Define the term binding energy<br>• Compare graphs of stable and unstable nuclei<br>• Interpret graph of binding energy per nucleon versus mass number<br>• Represent nuclear reactions in the form of equations<br>• Associate the release of energy in a nuclear reaction with a change in mass | • The strong nucleus force<br>• Nuclear properties<br>• Stable nuclei<br><br>• Mass-Energy relation, mass defect<br>• Binding energy per nucleon<br><br>• Nuclear fission and | |

| ***Competencies*** | ***Content*** | ***Suggested Activities*** |
|---|---|---|
| • Define the term nuclear fission<br>• Define the term nuclear fusion<br>• Distinguish between fission and fission. | fusion | |

## Assessment

The teacher should assess each students work continuously over the whole unit and compare it with the following description, based on the competencies, to determine whether the student has achieved the minimum required level.

**Students at minimum requirement level**

A student working at the minimum requirement level will be able to: define the terms atomic mass, isotopes isobars, radioactivity, mass defect, binding energy nuclear fission and fusion; describe the composition and size of a nucleus, the dual nature of matter, photo electric effect. alpha particle scattering experiment, Rutherford's model of an atom, Bohr model of energy levels; state Einstein's photoelectric equation, de Broglie's equation. mass-energy relation, radioactive decay law; use photoelectric equation, de Broglie's equation, and the radioactive decay law, the mass- energy relation to solve practical problems; **-** Describe Rutherford's model of atom; State the nature ,charge, and properties of alpha, beta, and gamma radiation; State the law of radioactive decay and explain the meaning of a half life; Write equations to illustrate alpha and beta decay; State how many protons and neutrons their are in a nuclide for which you are given the symbol; Interpret equations representing nuclear reactions indicating the nature of energy released; Identify the relationship between mass and energy; Explain what is meant by photo electric effect; Describe an experiment to demonstrate the emission of photo electrons; State how the rate of emissions of photo electrons and their energy depend upon the intensity and frequency of the incident radiation; Work through simple problems on half-life; Associate the release of energy in a nuclear reaction with a change in mass; Discus problems posed by radioactive waste; Represent nuclear reactions in the form of equations; Distinguish between fission and fission.

**Students above minimum requirement level**

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

**Students below minimum requirement level**

Students working below the minimum requirement level will require extra help if they are to catch up with rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.