Physics Syllabus, Grade 8

Grade 8 physics objectives

After completing grade 8 physics lessons students will be able to:

- Understand basic concepts of measurements, forces, static, kinematics and motion, mechanical energy, power, heat, temperature, sound and electricity;
- Develop basic manipulative skills related to measurements, force, motion, mechanical energy, power, heat, temperature, sound and electricity;
- Develop basic skills of performing practical activities in physics;
- Develop positive interest and attitude for physics.

Unit 1: Physics and measurement *(8 Periods)*

Unit outcomes: Students will be able to:

- Understand concepts related to basic measurements
- Develop skill of measuring volume, density and area; develop skills in measuring displacement, velocity, heat capacity.
- Develop skills in producing and evaluation of a design project applying the laws of physics in its construction.
- Appreciate the interrelatedness of all things.
- Use a wide range of possibilities for developing knowledge of the major concepts within physics.

Competencies	***Contents***	***Suggested Activities***
Students will be able to: • Apply the concept of area as a measure of squared units to many situations including 2D and 3D • Measure the sides of a rectangle, square and triangle • Calculate the areas of a rectangle, square and triangle using measured values • Measure the diameter of a circle infer its radius and calculate its area • Calculate the surface area of simple solids like the cube, the rectangular prism, and the square pyramid • Convert the area in m^2 to cm^2,mm^2,$km^2$and vice versa • Measure the sides of a rectangular block • Calculate the volume of a rectangular block using measured values	***1. Physics and measurement*** **1.1 Measuring area** *(2 periods)* • Area of rectangle, square, triangle and circle • Surface area of a solid	Students should appreciate that all measures of areas involve squared units and that any quantity of squared units represents some area, though not any specific regular figure. The S.I. unit of area is the metre^2. Students should measure the length and width of some rectangles and use the equation: Area of a rectangle = length x width to calculate the area and give an appropriate unit with their answer. They could measure rectangular objects such as a tabletop or a notebook, or the area of the floor of a room or a window or a wall. Students should select appropriate units (meters or cm) to express an area. Students should appreciate that a square is a special case of a rectangle. They should measure the length of the side of a square and use the equation: Area of a square = length of a side^2 to calculate the area and give an appropriate unit with their answer. Students should measure the base length and vertical height of a triangle and use the equation Are of a triangle = ½ base x vertical height to calculate the area and give an appropriate unit with their answer. Students should measure the diameter of a circle, infer the radius and use the equation: Area of a circle = π x radius^2 to calculate the area and give an appropriate unit with their answer. They should apply this technique to measurement of a circular base of a cylinder such as a glass container, a base of a water tank or circular area in a park. They should choose appropriate units for the measurement. Students should appreciate that in practical situations it is often easier to measure the diameter of an object than its radius, and that the radius is half the diameter. Students should measure the surface are of small or large rectangular boxes such as cartons which might be cubes, or larger structures such as a school building or the back of a rectangular truck.

Competencies	*Contents*	*Suggested Activities*
• Measure the height and radius of a cylinder • Calculate the volume of a cylinder using measured values • Measure the volume of a liquid using measuring cylinder • Measure the volume of irregular-shaped bodies using displacement method • Convert the volume in m^3 to cm^3, mm3, and litre and vice versa. • Define the term density • Determine the density of a given body by measuring its mass and volume • Use the definition of density to calculate the density of a body • Measure the density of irregular shaped bodies using displacement method	**1.2 Measuring Volume** *(2 periods)* • Volume of regular shaped body • Volume of liquids • Volume of irregular shaped bodies **1.3 Measuring density** *(2 periods)* • Density of regular shaped body • Density of irregular shaped bodies • Density of liquids • Hydrometer	Students should measure the surface area of a geometric solid such as a square pyramid. This could be a cardboard model or dimensions of a large structure such as a pyramid at Giza. Total Height = 139 m. Length of a side on its base = 220 meters. Distance from midpoint of its side to the top = 176. Students should appreciate that the S.I. units of volume is the $metre^3$. All cubic units represent volumes. Students should measure the sides of a rectangular block and use the equation: Volume = length x width x height to calculate the volume of the block and give an appropriate unit with their answer. They should also extend the idea to larger structures such as buildings, or rectangular shaped trucks. They should choose the appropriate unit, m^3 or cm^3. Students should measure the height and radius of cylinder and use the equation: Volume = area of base x height to calculate the volume of the cylinder and give an appropriate unit with their answer. They should extend the investigation to volumes of cylinders such as glass cylinders, or cylinders used to contain liquids like paint or larger cylinders used to contain and store water. **Irregular shaped objects: Volume by displacement.** Volumes cannot always be calculated. Students should be provided with a volume of a liquid in a beaker. They should pour this into a measuring cylinder to measure its volume and give an appropriate unit. Students should be given a small, irregular-shaped object such as a stone or piece of rubber. They should lower this into the measuring cylinder containing a known volume of water and measure the new volume. They should subtract the original volume to give the volume of the object. This change in water level caused by immersion is **displacement.** Students could also measure the volume using a displacement can which captures overflow and a measuring cylinder. Ask students to suggest how they could find the volume of an object that does not sink in the water. Students should understand that the density of a material is defined by the equation: $\text{Density} = \frac{\text{mass}}{\text{volume}}$ The S.I. unit of density is the kg/m^3. or g/m^3 . Students should compare density of many shaped stones in the experiment. They should determine that the density of the stones, if they are similar, density is the same independent of shape. They should determine the density of several metals, even with irregular shapes such as bolts or pieces of iron.

Competencies	***Contents***	***Suggested Activities***
• Define what a dimensional expression is • Express the dimensions of area, volume, density speed, acceleration, force, work, and power	**1.4 Dimensional expression of physical quantities** *(1 period)*	They should confirm that the density of each kind of metal is the same independent of shape. Include lead objects in the measurements. Students could determine the mass and volume of a number of different objects, both regular and irregular, made of different materials, for example a stone, a glass marble, a ping-pong ball and a piece of plastic. One or more object should float, like wood or cork. Use a wire to submerge it. They could then calculate the density of each object. They should generally observe and conclude that if the density is less than 1.0, the object floats by making a general qualitative point plot of object on the horizontal and density on the vertical axis. Should appreciate the density of any liquids can be determined using hydrometer Students should appreciate that all quantities cam be expressed in terms of base quantities and their units. The primary units are mass, length, and time. All others are derived from these. • Mass – kilogram • Length – metre • Time – second • Current – ampere • Temperature – Kelvin Students should express and express a variety of quantities in terms of their base units including: • Area – L^2 • Volume –L^3 • Density – ML^{-3} • Speed – LT^{-1} • Acceleration – LT^{-2} Other quantities can be expressed in base units but the expressions are often complex. Named units are commonly used. • Force – Newton or pound (English) • Work – Joule • Power – Watt Students should identify each primary unit with the physical quantity it measures. **Confirming Understanding**: "Unit Jeopardy: is a whole class game that engages all students in building understanding and association of the unit with the quantity it measures. See the attached sheet on "UNIT JEOPARDY". "Jeopardy" is a game that uses a 5x5 board on which there are answers in each of the 25 boxes. Students must give the question for which the entry is an answer. Example: "Joules" student responds, "What is a quantity of work?" or "cm^3" Then the student responds "What is a volume?" Jeopardy is a very general format. It strongly engages the whole class. One can also do "Area Jeopardy" in which the boxes contain formulas. The student must read the formula as a question: Ex. "π r^2" the student responds

Competencies	***Contents***	***Suggested Activities***
		"What is the area of a circle? Another tougher example is, "$\pi R^2 - \pi r^2$" Answer: "what is the area of one circle subtracted from another". Or "10 x 25" Answer "What is the area of a rectangle 10x25". A tough one is "$4(10x25) + 10^2$ ".Answer: "what is the surface area of a rectangular box with sides 10 x 10 x 25" Simpler formulas may be used. These "bottom" answers are the harder questions on a Jeopardy board.
• Define the scientific notation as a simple method of writing very large and very small numbers • Use scientific notation to write very large or small numbers • Define the term prefix • Use prefixes to write very large or small numbers • Identify common quantities with the appropriate unit that will measure them.	**1.5 Scientific notation** *(1 period)* • Prefixes of units	Students should appreciate that writing very large numbers or very small umbers involves including several zeros. Ask students why this might be a problem. They may suggest: • The numbers are tedious to write • The numbers may take up a lot of space • Errors may easily be made misreading the number of zeros Students should appreciate that numbers can be written using a power of 10. The general format for scientific notation is: a.bcde x 10^n e.g. 1.234 x 10^4, 3.987 x 10^{-2} Students should practice converting numbers into scientific notation by: • Writing the number with a decimal point between the first digit and second digit • Counting the power of 10 needed to move the decimal place back to its original position 3 00 000 000 = 3.0 x 10^8 0.000 000 000 000 128 = 1.28 x 10^{-13} Students should appreciate that certain powers of 10 can be implied by writing a short word before the name of a unit and that this I is called a prefix. Students should understand that: • Mega = 10^6 • Kilo = 10^3 • Milli = 10^{-3} • Micro = 10^{-6} Students should appreciate that these prefixes can be used with all S.I. units e.g. • 1 megawatt = 10^6 = 1 000 000 watts • 1 kilometre = 10^3 = 1 000 metres • 1 milliamp = 10^{-3} = 0.001 amps • 1 milligram = 10^{-6} = 0.000 001 grams Students could use the following prefixes with S.I. units: • Mega – M - e.g. MW • Kilo – k - e.g. km • Milli – m - e.g. mA • Micro - μ - μg

Competencies	***Contents***	***Suggested Activities***
		Activity: Students should use another version of "UNIT JEOPARDY" called "Quantity Jeopardy" to associate common experiences with the appropriate unit. Ex: 50 watts The student to be right must respond "What is a measure of an electric light?" or "1.5 milligrams" The student must respond "What is the weight of a fly?" , or. "500 megawatts" The student must answer "What is the power output of a power plant or a damn?" or "60 cubic meters" The student would respond, "What is the volume of a room 5mx3mx4m ?" The game builds capacity in interpreting magnitudes of units with appropriate observables. Student measurements from the previous activity become the "Quantity Jeopardy" questions. The students write the cards for the game.

Assessment

The teacher should assess each student's 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 terms and concepts like density, dimensional expression, scientific notation; measure sides of rectangle, square , triangle, radius of a circle, volume of a liquid, volume of irregular shaped bodies; calculate areas and volumes of rectangular bodies; give the dimensions of area, volume, density, speed, acceleration, force work and power; use scientific notations and prefixes to write large and small numbers.

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 the 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: Motion in one dimension *(10 Periods)*

Unit outcomes: Students will be able to:

- Understand concepts related to force and uniform motion
- Develop skill of manipulating problems related to statics and uniform motion ;
- Appreciate the interrelatedness of all things.
- Use a wide range of possibilities for developing knowledge of the major concepts within physics.

Competencies	***Contents***	***Suggested Activities***
Students will be able to: • Name the types of forces in nature	***2. Motion in one dimension*** **2.1 Forces in Physics** *(2 periods)* • Kinds of forces	The instructor invites students to name all the kinds of forces that they know about. He writes them on the board, grouping them as he goes. Some "forces" are not physical forces such as "mental force" or "spiritual force". The physical forces are listed together; others are excluded when each has been discussed. Students should know what constitutes a force studied in physics and what does not. Listings should include: gravity, friction, magnetic force, electric force, spring force, and force from collisions, perhaps centripetal force and buoyancy. If a student brings up an incorrect "force" such as the "force that keeps a ball flying" the student articulates the "impetus" theory. This means the student thinks a force is needed to keep an object moving. The instructor reminds the student this is not true from studies in grade 7. This segment re-confirms some very difficult ideas about force and motion that need constant review.
• Distinguish between contact and non contact forces		For each of the physical forces the instructor inquires, "Is any forces in the list effective only on contact between two objects?" Students should know that friction, spring force, and force on collisions are contact forces. The instructor asks, "Are any forces capable of acting at a distance on an object?" Students should know that gravity, magnetism and electric force are very different from others; they can pull or push objects without touching them.
• State Newton's third law	• Revisiting Newton's 3^{rd} Law "no motion" and balanced forces	The instructor revisits Newton's first law in a qualitative way to emphasize difficult concepts. The instructor asks, "Do you have any forces acting on you, personally now?" He makes lists. "Air pressure" should be excluded; it is a pressure, not a force. Students should appreciate that a force is a push or pull. Pressures are different; they will study pressure this year. Invite pairs of students to push on each other's hands. How many total forces are acting on each person? Students must appreciate that forces always come in pairs: bottom on the chair and chair on the bottom, 1st hand on the 2^{nd} hand and 2^{nd} hand on the first. Each student puts a book or object on his or her lap. Students should be able to count the forces. The instructor inquires about the size of the forces. This is a very difficult point. It is quite counter intuitive. From previous study some student should voice "The forces are equal." Another will voice, "The heavier one pushes more."

Competencies	*Contents*	*Suggested Activities*
• Identify the state of 'no motion ' and 'balanced forces'		Peer Instruction: Groups of 4-6 students discuss which is correct. I'm heavier than the chair, do I push more on it? The teacher uses card voting to assess understanding. One member in each group holds up 1 saying the group means "I push more." Or 2 meaning the group believes "I push the same". The teacher views responses. If 70% are correct, the instructor confirms the answer and moves on. If there are more errors, the instructor gives a 5 min. talk about forces and balanced forces and Newton's 3rd law. If the forces are unequal, on of you, the chair or you will be moving faster and faster. The instructor gives another probe. "What about the force on your hands? Is it equal or is the bigger person pushing more?" The voting continues again. Students should understand that if there is no net force then the person is either not moving or moving at a constant rate and not accelerating. The instructor invites students to slowly increase the push on each other's hands until there is constant motion. The instructor invites a student to ride a bicycle across the front of the group. What forces are on the bicycle/human system as it moves at a constant rate? Peer Instruction: students vote with cards. 1, 2, 3, 4, 5, 6. The instructor talks a bit about paired forces when there is constant motion and invites groups to discuss the right answer. Students should be able to make a correct assessment of the number of forces acting on a non-accelerating object in motion. Earth's force on the bicycle and person, bicycle and person's force on earth. These balances. Tires force back on the road. Road's force forward on the bicycle/human system. This road force is from friction. If the bicycle were on ice, pedalling would do no good. This is a balance force. Students must be able to recognize balanced forces in nature. Students should recognize that a balanced force will produce either no motion or motion at a constant speed. If the bicycle accelerates or decelerates there is an unbalanced force on it from either friction or harder peddling pushing the bike forward faster and faster. Students should recognize when unbalanced forces occur and accelerations can happen. Students should dialogue about what the student's peddling is doing when it is moving in a constant speed. Students should recognize that friction with the road is what pushes the bicycle. The person's peddling pushes back against the friction on the tires. Students should recognize that if the two are equal, there is no speeding up. Students should recognize that if the peddling stops, then there is an unbalanced force from friction. The bike must slow down.
• Define the terms average speed, velocity, acceleration, uniform motion ,uniformly acceleration motion • Distinguish between uniform motion and uniformly accelerated	**2. 2 Motion in one dimension** *(5 period)* **2.2.1 Uniform motion** • Average speed • velocity	Opening Activity: Whole class does "The Human Measuring Line". See the attached description of this whole class laboratory. The lab design incorporates "Teaching by Bridging Metaphors". Students set up "The Human Measuring Line" and make dot plots of motions of people walking or riding on a bicycle. Ex. A dot plot of constant motion would look like: • • • • • • • • • • • • where a dot is placed at a position every 2 seconds, for example.

Competencies	***Contents***	***Suggested Activities***
motion		Ex. A dot plot of accelerated motion would look like: The students should make dot plots on the large tape in the "Human Measuring Line and transfer that to copies at their seats. They construct a table of time, distance and average speed defined as Distance travelled in the interval divided by time it took. • • • • • • •
	2.2.2 uniformly accelerated motion • acceleration	Students in "The Human Measuring Line" created their own qualitative dot plot representation of motion. Using the tables generated from quantitative measurements, students generate values for average velocity in an interval. Students characterize acceleration or deceleration as changing velocity over time.
• represent uniform motion using dot plots	**2.2.3 Representation of uniform motion and accelerated motion qualitatively using dot plots and quantitatively using tables**.	Students should understand that the average speed of a body is given by the equation and calculate average speed for an interval by this method: $\text{Average speed} = \frac{\text{distance moved}}{\text{time taken}}$ and the S.I. unit of speed is the metre per second or m/s. Velocity is speed in a given direction so velocity is defined by the equation $\text{Velocity} = \frac{\text{displacement}}{\text{time taken}}$ and has the same unit as speed. Students should appreciate the difference between speed and velocity – velocity is the speed in a particular direction and between distance and displacement – displacement is how far something has travelled in a particular direction. Students should understand that the acceleration of a body is, qualitatively the rate of change of the speed of an object over time. As velocity is length/time, rate of change of velocity is length/time/time or Lengthy/t^2.
• Define the slope as m=vertical increase/horizontal increase • Calculate the slope of a given linear graph • Identify the physical quantities represented by the slope of s-t and v-t graphs	**2.3 Graphical representation of motion on a Cartesian plot** *(4 periods)* • Graphical representation Uniform motion d vs. t and v vs. t graphs	Students transfer the values in the tables they made to a Cartesian graph. They demonstrate understanding of displacement in uniform motion by characterizing a graph of uniform motion as a slanted line in a distance vs. time plot. For fast objects the line is steep. For slow objects the line is less steep. They demonstrate understanding of velocity in uniform motion by characterizing a graph of uniform motion as a straight line in a velocity vs. time plot. Slow objects have lower horizontal lines, faster objects have higher horizontal lines. Students, using v vs. t plots should be able to calculate distance travelled for constant velocity situations. The plots should include a significant numbers of segmented graphs. Students should construct their own constant velocity stories. Ex: I rode my bike to my grandmother's house at 6 km/hr. It is flat riding for 5 minutes then there was a hill. I went at 2km/hr up the hill. After 3 minutes. I met a friend and stopped to talk for 5 minutes. I went on

Competencies	***Contents***	***Suggested Activities***
• Identify the physical quantities represented by the area under the v-t and a-t graphs • Read and interpret s-t ,v-t, and a-t graphs	• Graphical representation of Uniformly accelerated motion s vs. t and v vs. t graphs	at 2km/hr to my grandmother's house." Plot a v vs. t for this. It is important that students make up their own stories. If they decide to make a story that goes back to the starting point, they must represent the vector velocity as a negative speed. Students should construct d vs. t graphs from simple v vs. t graphs. If an object is moving at a constant speed, the d vs. t must be a straight line, going up or down. If you are moving at 6 km/hr, every hour you are 6 km further away. Every ½ hour you are 3 km further away. Every 1/3 hour you are 2 km further away. From the d vs. t graphs students associate slope as $$\text{Speed} = m = \frac{\text{vertical increase}}{\text{horizontal increase}}$$ Students should practice calculating the slopes of linear graphs that they create. Students should appreciate that we can plot graphs to represent the motion of a body. They should be aware that: • a distance-time graph shows the distance travelled by a body (y-axis) against time (x-axis) • the slope of a distance-time graph is the distance travelled/time taken, so the slope of a distance-time graph represents the speed • the steeper the slope the greater the speed • a horizontal line represents a stationary body. Students could practice plotting distance-time graphs from stories that they write. Students should practice matching stories with graphs. The class should confirm understanding with "Bicycle Story Jeopardy". Each box contains a graph, perhaps made by a student. The student must respond to a segmented s vs t graph, for example. "I waited 3 minutes, and then went slowly for 2 minutes then stopped." Students should be aware that: • a velocity-time graph shows the velocity of a body (y-axis) against time (y-axis) • the slope of a velocity-time graph is the change in speed /time taken for the change, so the slope of a velocity-time graph represents the acceleration • the steeper the slope the greater the acceleration • a horizontal line it represents a body moving at a constant velocity (i.e. the acceleration = zero). Students should appreciate that the area under a velocity-time graph is the velocity x time, so the area under a velocity-time graph represents the distance travelled. Students should practice calculating the distance travelled by a body from velocity-time graphs. Students should practice reading and interpreting various distance-time, and velocity-time graphs. Distance-time graphs should include examples where an object is:

Competencies	***Contents***	***Suggested Activities***
		• stationary • moving at a constant speed • accelerating (using dot plots only) • decelerating (using dot plots only) Velocity-time graphs should include examples where an object is: • moving at constant velocity – segmented graphs Students at this level do not construct v vs t plots from acceleration plots.

Assessment

The teacher should assess each student's 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 terms and concepts like average speed, velocity. Acceleration and slope; read and interpret S-t and ,V-t graphs

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 the 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: Pressure *(9 Periods)*

Unit outcomes: Students will be able to:

- Understand concepts related to pressure;
- Develop skill of manipulating problems related to pressure;
- Appreciate the interrelatedness of all things;
- Use a wide range of possibilities for developing knowledge of the major concepts within physics

Competences	***Contents***	***Suggested Activities***
Students will be able to: • Define the term pressure • Relate atmospheric pressure, which generally is invisible to an observable force. • State the dimension of pressure and define its SI units • Tell how atmospheric pressure is measured in terms of the columns of liquids it supports • Explain the variation of atmospheric pressure with altitude	***3. Pressure*** **3.1 Atmospheric pressure** *(1 period)* • Source of air pressure • Barometer	Introduction: Classroom activity – Crush a Can. See attachment describing the classroom demo "Crush a can" Students should be able to answer: What crushed the can? What was the function of the heat and the steam inside the can? What changed: mass, volume density, temperature. Which went up, went down, or stayed the same. Why cannot students, by hand, crush the can? Would a smaller can be crushed the same way? What kind of container would not be crushed? Why Students could be asked to suggest what they think is meant by 'atmospheric pressure'. Students should identify the source of the force that crushed the can as the weight of all of the air above it, all the way to top of the atmosphere up 24,000 meters or 24 km of air. They should appreciate that the air has weight. It is the weight of this air presses down that produces atmospheric pressure. Students should appreciate that every square cm on the surface, including plants, people, animals has this force on them. It even acts on the underside of a table or chair. Students should answer the "what if" questions: what if I go up a tall mountain, air pressure will: What if I go half way up only: the pressure will: What if I'm high up in an airplane that does not pressurize its cabin; the air pressure will: Students should appreciate that atmospheric pressure acts equally in all directions.
• Use the definition of pressure P=F/A to solve problems related to pressure	**3.2 Definition and unit of pressure** *(1 period)*	Students should identify air pressure is a force caused by the weight of a column of air and explain why the units of force, Newton, do not really serve to measure it. Students must explain why it makes more sense to measure air pressure as a force per square unit, not an absolute measure of force, the Newton. Pressure has the definition Pressure = Force on an area/measurement of the area. Its units are Nektons per square unit in SI standards. Applied directly to air pressure the definition has practical problems. The force on 1 square meter of 24 km from the air above is about 100,000 Newton, or about 10 tonnes, the downward force of several large trucks or 5 elephants. The students should appreciate why the unit is just too large. Atmospheric pressure is commonly

Competences	Contents	Suggested Activities
		measured in standard units of atmospheres, where one atmosphere is the air pressure at sea level at a 20 degrees C. Other units for air pressure are millimetres of Mercury (760 mm-Hg) or kilo Pascals Air pressure at sea level is 101.3 kPascals.
	3.3 Measuring Air pressure *(2 periods)*	Students begin an inquiry on how to measure air pressure. The instructor takes a long closed ended glass tube fills it with water, covers the end and puts it into a dish of water. Students answer "Why doesn't the water fall out of the tube?" Students should recognize that the inverted closed tube with the weight of the liquid inside form a balance with the pressure of the atmosphere on the surface of the water in the dish. Students should know that it takes a very long tube of water to balance the atmospheric pressure of earth's 24 km of air above it. The first barometer was a wooden tube 10.5 m high with a glass window at the top. Students should explain why such a high tube was needed. They should explain why a shorter tube would not show the pressure. Students should explain three serious disadvantages of the water barometer. Students should answer the question: If water has a weight of 10 Nt per cm^3, then what was the force on the bottom of a 10.5 m high column of water that the atmosphere is holding up? Students should answer the question: Why don't we feel this pressure?
	• Aneroid barometers	Later barometers were made with the liquid mercury. One cm^2 of mercury has 13.3 times the mass of one cubic cm of water. Students should predict the height of a column of a mercury barometer. Students should be able to explain why mercury was selected for barometers giving four advantages: • It is dense and therefore only a relatively short column is needed • It is easy to see • It doesn't freeze in very cold weather • Very little is lost by evaporation Students should know that standard atmospheric pressure supports a column of 760 mm of mercury (760 mm Hg). Atmospheric pressure varies slightly from day to day. Mercury is exceedingly poisonous. Modern barometers use a non-liquid design. They are basically small cans that have one lid that is made from a very thin piece of metal. It is connected by a lever to a pointer. Students should explain how this new design works. They should explain why it is similar to the can crush at the start of the unit. Students should appreciate that the higher we go above sea level the less the weight of the air above us, so atmospheric pressure decreases with increasing altitude. Students could research the value of atmospheric pressure at different heights. Students could research the standard atmospheric pressure in Addis Ababa and: • Explain why it is less than at sea level • Discuss some of the effects • For most of the world, except Tibet and Bolivia, water boils at 100 degrees C. Boil water at

Competences	*Contents*	*Suggested Activities*
		Addis Ababa and what is the result? Students should calculate the air pressure on closed simple objects like boxes or bottles. They should also explain why they don't collapse. Students should understand that the general pressure is the force per unit area. This is given by the equation: $$\text{Pressure} = \frac{\text{force}}{\text{area}}$$ It does not depend on air or water. The S.I. unit of pressure is the N/m^2 which is the same as the Pascal, P. Objects on the earth exert a pressure caused by the force of gravity on the earth beneath them.
• Use the relation P=ρgh to calculate the pressure due to a liquid at rest • State the factors that affect pressure due to a liquid at rest	**3.4 Liquid pressure** *(2 periods)*	Students should appreciate that an object such as a rectangular block will exert a different pressure on the ground depending on which of its sides it is placed. Using the general definition, students will calculate the pressure of some boxes, a brick, or other regular solids on the floor. Find some objects with pressures of greater than 10nt/m squared. Find some with pressures of less than 10 N/m squared. Students should clearly state what parts of the structure or design make the high pressure high. What elements make the pressure low? For practical examples students should estimate the pressure on the ground of an elephant against the pressure of a woman wearing stiletto heals Students could discuss some examples of practical situations where spreading the weight of an object over a large area usefully reduces the pressure. Students will make a list of four common situations where the object, person, or machine, in order to function must have to exert a low pressure on the ground. They must be clear how the lower pressure is achieved. (big feet, wide tires, wide platforms) Students will make a second list of four common situations where the object, person, or machine, in order to function must have to exert a very high pressure on the object it is contacting. The student must be clear about how these high readings of pressure are achieved. What would make them even higher. (nails, knives, saws, pins) Class activity: Light Foot = Heavy Foot Students could find the pressure they exert on the floor. They could use scales to find their own mass and multiply this by g (approx 10 N/kg) to find their weight. They could draw around their feet onto cm squared paper to determine the area of their feet in contact with the ground. Students put up their own measurements by groups of 6-8 on a big chart. The units of the area should be square cm. The range should be from 50 cm^2 to about 200 cm^2 Its vertical axis is "Area of Foot." Its horizontal axis is weight (kg x 10). Students should collaborate to find out which area of the chart will have people with the lightest pressure. Which area will have the heaviest pressure. Which student is the light foot. If possible get some measures for camels or

Competences	*Contents*	*Suggested Activities*
		donkeys and put them on the chart. Put on the measurements of the same person in high heels. Students should understand that in a liquid • Pressure increases with depth because the deeper you go down in a liquid the greater the weight of liquid above you. • This can be demonstrated using a tall can, with several holes drilled into its side, filled with water. The water spurts out fastest and furthest from the lowest hole because the pressure there is greatest. • Pressure at one depth acts in all directions. This can be demonstrated using a can, with several holes drilled in it at the same level, filled with water. The water spurts out equally fast and far from each hole because the pressure at this depth is the same in all directions. • Pressure depends on the density of the liquid. The more dense the liquid the greater the pressure at any given depth. Students should understand that the pressure at a point in a liquid can be calculated using the equation $$P=\rho gh$$ Where P = pressure in N/m^2 ρ = density in kg/m^3 g = acceleration due to gravity in $m/s^2 = 10$ h = height of liquid above the point. The equation can be rearranged to make more sensible reading by looking at units . $P=\rho gh$ in units is (Kg/m^3) which is density times height. Kilograms times g gives Newtons which is force. The equation really is Force/square area. Multiplying by the height of the column converts to the force of the whole column of liquid. Students should carry out calculations to find the pressure exerted by columns of liquids such as water or oil.
• State Pascal's principle in words • Use Pascal's principle to describe the workings of a hydraulic press	**3.5 Pascal's principle** *(1 period)* • The hydraulic press • Braking system	Students should appreciate that going deeper into the ocean increases pressure on the object submerging. The equation is $$\text{Pressure} = \frac{\text{force from the water above}}{\text{area}}$$ Ignoring air pressure students should find the pressure per square meter at a depth of 10 m, at a depth of 100 m, at a depth of 1000 m, at the bottom of the ocean at 2,000 m. They should calculate the total pressure on a cubic submarine parked on the ocean floor. Students should be able to state Pascal's principle: pressure applied to any point of a liquid in a closed container is transmitted equally to every other point in the liquid. Pascal's principle is easily commonly applied in hydraulic systems such as lifts for automobiles. If two cylinders are connected students must demonstrate understanding that the pressure is the

Competences	***Contents***	***Suggested Activities***
		same in both. This lets a smaller force maintain elevation of a much larger one. $$\frac{F_1}{A_1} = \Pr essure = \frac{F_2}{A_2}$$ Students should show understanding of linked cylinders. If F_1= the force from an automobile of 10,000 Nt on a large cylinder, say 6 m^2, then, a small cylinder with area .01 m^2 will support the automobile $$\frac{F_1}{.01m^2} = \Pr essure = \frac{10{,}000Nt}{6m^2}$$ Students must clarify verbally how Pascal's principle shows that linked cylinders function much like levers. F_1 is much smaller than 10,000 Nt F_1 is 16.6 Nt. Peer Instruction on Pascal's principle.
• use Pascal's principle to solve simple problems		Students should understand that a hydraulic press works because a force is applied to a piston with a small area, producing a pressure that is transmitted through a liquid. The liquid pressure acts on a piston with a much larger area producing a much larger force. Students could study some industrial examples of such presses such as: • Compressing bales of cotton • Compressing waste paper • Shaping steel car bodies • Crushing scrap metal
• List some applications of pressure caused by liquids	**3.6 Applications of pressure** *(2 periods)* • siphon • lift pump	Students should understand how atmospheric pressure is used to operate a lift pump and so draw water from a well. Students should be able to draw and explain the operation of a lift pump. Students should discuss the limitations of a lift pump. Students could compare the operation of a lift pump with that of a force pump. Students should understand how atmospheric pressure is used to fill a syringe with a liquid. If the nozzle of the syringe is placed under the surface of the liquid and the piston is drawn back the pressure in the barrel is reduced and atmospheric pressure forces the liquid up into it. Students could be given a syringe and asked to fill it and so deduce how the syringe works. Students should understand that when a rubber sucker is pressed onto a flat surface, and the air is squeezed out from underneath it, atmospheric pressure keeps it in place. Students could look at some applications of this such as attaching notices to windows or in industry for moving large metal sheets.

Competences	Contents	Suggested Activities
	• syringe	Students should understand that a toilet is fundamentally a siphon. It will flush with a bucket of water poured in, not just by pulling a chain. The goose neck in the toilet is a siphon.
• List some applications involving atmospheric pressure	• Toilet	Students should understand that when they suck drink through a straw they are lowering the pressure of the air in the straw. So atmospheric pressure on the surface of the drink pushes it up into the straw.
	• rubber sucker • straw	Students could observe what happens if they make a small hole in the side of the straw or if they try and suck drink from a container with an opening that fits tightly around the straw. Students should try and explain their observations in terms of atmospheric pressure.

Assessment

The teacher should assess each student's 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 term pressure; tell the dimension of pressure, factors affecting pressure in liquids, application of liquids and atmospheric pressure, how atmospheric pressure is measured; use the relations $P=F/A$ and $P=\rho gh$ to calculate simple numerical problems involving pressure in solids and liquids.

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 the 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: Heat energy *(8 Periods)*

Unit outcomes: Students will be able to:

- Understand concepts related to heat energy;
- Develop skill of manipulating problems related to heat energy ;
- Appreciate the interrelatedness of all things;
- Use a wide range of possibilities for developing knowledge of the major concepts within physics

Competences	***Contents***	***Suggested Activities***
Students will be able to: • Define the term heat • Describe the mechanisms of heat transfer • Identify and describe the difference between heat and temperature.	***4. Heat energy*** **4.1 Transfer of heat** *(4 periods)* • Conduction - heat conductors and insulators - method of controlling heat loss	Introduction: Classroom activity – the Blubber Mit. See attached document describing the Blubber Mit construction and experiment. A twin plastic sack is packed with fat so that the inside has about 1-2 cm of fat between the inside and outside. Students put their hand into the blubber mit and put it in ice water. Another student puts his hand into the same bucket with no insulation. Students repeat the experiment with very hot water. Whose hand starts feeling pain first. The activities follow a "Bridging Strategy" to teach about heat and temperature. Concrete qualitative models are built first, then the models are quantized to more formal expressions. Students discuss how a substance like fat can both keep out cold and heat. Students make a list of animals that have protection from the cold like the blubber mit. Students describe how both the cold and heat entered the hand without protection. This is transfer of heat by conduction, by contact. Students learn to characterize insulators as substances that prevent conduction of heat. Students hypothesize other substances to put into the space of the blubber mit that might work. Africa is generally a warm place. Students dialogue about why zebra, lions, and elephants don't have layers of fat to keep the heat out. Students appreciate that insulation like fat would actually be like a human wearing a very warm coat. It will keep heat outside out but keep heat inside in. The animals will cook themselves. Students show understanding by listing at least four similar situations where insulators are not advantageous. Students dialog about what animals and humans need in very warm climates, insulators, or conductors to get rid of heat. What conductors of heat do animals have? Students make lists and seek patterns and make general statements about how people and animals get rid of heat by conduction. They may also get rid of heat by other methods. Students explore through an experiment the difference between heat and temperature. Heat is not temperature; this is a common confusion. Students take a large piece of metal from boiling water and a much smaller piece from the same pot. They place these on a large piece of wax. Students observe and conclude that the larger piece had more heat but was at the same temperature. It melted more wax. Alternatively, students place the metals in separate jars with equal amounts of water. Thermometers measure which jars got warmer.

Competences	***Contents***	***Suggested Activities***
• Name the three mechanisms of heat transfer • Describe the role of convection in everyday phenomena	• Convection • Radiation	Students should be able to define heat as the energy which is transferred from one place to another due to a temperature difference between them. Students articulate that heat never flows to a hotter place. Cold never flows to a colder place. Humans and animals get rid of heat by convection, a process that uses air or water as a medium of transfer. Students make links to the idea of how humans and animals use convection to get rid of body heat. They make lists of at least 10 animals and describe how they remove extra heat. They look for patterns to find a few basic strategies. Students demonstrate understanding of convection by listing at least four machines or systems that remove heat from their surroundings by convection with very little conduction. Students demonstrate understanding of the difference by making a parallel list of machines or systems that remove cold from the environment that means they supply heat using convection. Students should be able to name the three main methods of heat transfer: conduction, convection and radiation. Students should understand that • conduction occurs mainly in solids • most liquids and all gases are poor conductors • poor conductors are called insulators • materials that contain trapped air are good insulators • metals are good conductors Students should be able to discuss the difference between conduction of heat and conduction of electricity. Discuss the difference between heat and electric conduction. Students could carry out a simple experiment to test which of a number of different materials is the best insulator for a cup of hot water. Wrap cups of hot water in sheets of materials such as newspaper, cotton, aluminium, felt and cotton wool. Record the initial temperature and record the temperature again after ten minutes of cooling. Students should conclude which is the best conductor. It is important to put lids on the cups and to stand them on an insulating mat and covering the thermometers from the sun. Ask students how they can make this a fair test e.g. by using the same initial temperature of water and using the same thickness of the material under test for each cup. Students could watch a demonstration to determine which of a number of metals rods, e.g. copper, steel, aluminium, wood, glass, plastic and brass, is the best conductor. Each rod has a drawing pin stuck on at one end with wax or petroleum jelly. The other ends of the rod are heated together in boiling water. Heat is conducted along the rods and the wax or jelly melts and the pin falls off. Students should conclude which rod is the best conductor. Which are the worst conductors of heat.

Competences	***Contents***	***Suggested Activities***
• Identify that energy transfer may take place by conduction, convection, and radiation • Tell how insulation is used to reduce heat losses from buildings and human body • Classify materials as good and poor conductors of heat		Students should discuss some everyday applications of thermal conduction and insulation such as: • metals pans for cooking • wooden/plastic handles on pans • metal radiators in motor car engines • insulating materials in buildings Students should understand that • convection takes place in fluids (liquids and gases) • when a fluid is heated it expands • the fluid becomes less dense and rises • the warm fluid is replaced by cooler, denser fluid • the resulting convection current transfers heat throughout the fluid. Students could produce a labelled diagram, using the correct words, to show their understanding of convection currents. Students could carry out experiments to observe convection. These could include: • suspending a spiral of card above heat sources and observing the spiral being rotated by the rising warm air • using a smoke box in which a burning candle is placed in one side of the container. Cold air is drawn down one chimney and hot, smoky air rises out of the other - this can be demonstrated using smouldering wooden spills • using a large beaker of water with a small potassium manganate (VII) crystal placed at the bottom. The beaker is heated gently from underneath by a heat source. The convection currents set up in the water can be seen as the coloured potassium manganate (VII) dissolves and is carried up by the convection currents. The whole class confirms understanding using “Heat Jeopardy”. The board is populated by cards the student made in previous activities. These are the answers to “Heat Jeopardy” example “An elephant holding ears out” answer “what is conduction? “a hippo going in the water” answer “what is conduction? A lion breathing very heavily. Answer: What is convection? An air conditioner. “What is Convection?” Peer Instruction on Heat: Pose conceptual question to confirm understanding. Students should be able to describe the role of convection in everyday phenomena including: • boiling water in a pan • hot water boiler and storage tank systems • land and sea breezes

Competences	***Contents***	***Suggested Activities***
		Students should understand that • heat radiation is the transfer of energy by infra-red waves • infra-red waves are part of the electromagnetic spectrum • all objects emit heat radiation • the hotter an object the more radiation it emits • heat radiation can travel through a vacuum such as space • this is the method via which we get heat from the Sun. Students should understand that dark, matt surfaces are good absorbers and emitters of radiation and white, shiny, surfaces are poor absorbers and emitters of radiation. Students could carry out an experiment to find out which surface is the best absorber of radiation and the best emitter or radiation using two identical cans, one polished and shiny and the other covered with matt black paint. Best absorber of radiation: • equal volumes of cold water are placed in each can • a thermometer is placed in each can • the cans are left in sunlight • the temperatures are recorded at regular intervals Students could present the data gathered as graphs. They should interpret the data in terms of which surface is the best absorber of heat. Best emitter of radiation: • equal volumes of hot water are placed in each can • a thermometer is placed in each can • the cans are left on the bench • the temperatures are recorded at regular intervals Students could present the data gathered as graphs. They should interpret the data in terms of which surface is the best emitter of heat. Students should discuss why it is important in each experiment to use the same volume of water at the same initial temperature in each beaker. Most African countries are warm. It is a challenge to find ways to keep people and buildings cool. Students should be able to describe and explain some ways in which insulation is used to reduce excess heat from the sun in buildings. • Insulation in walls. • cavity wall insulation. • Contact with the earth • Use of special materials for flooring and walls. • Which materials make the best roofing, which make the worst

Competences	***Contents***	***Suggested Activities***
		GROUP DESIGN PROJECT: This is an engineering project which will show how students can apply the physical laws to solve everyday problems. Students should make a list of good materials for building a house that will remain cool in hot weather. They should explain why very large churches and mosques are always cooler inside that the outside buildings. They have a huge capacity to store heat or cold with all the stone. The sun cannot warm them easily. Student groups should make a design for a house for their family that will be cool most of the year. They will pick materials for the walls, flooring and roof. They must also include a way to heat the house on cold days. Assessment: the group must present their design before the class and respond to the six conditions for a good design. See document Science vs. Engineering: Inquiry vs. Design. To show understanding of conduction and efficiency, students should consider materials to build a house in a cold country like Sweden or Canada. How are building materials very different? Swedes or Canadians never build out of stone; it stores winter cold much too well. They use wood for their houses and have basements to keep away from contacting the very cold earth. Windows always face south.
• Define the term 'specific heat capacity' of a body • State the dimension and unit of heat and specific heat capacity • Use the formula C=Q/mΔT to calculate the specific heat capacity of a material	**4.2 Quantity of heat** *(4 periods)* • Specific heat capacity	Students should be able to define the specific heat capacity (s.h.c.) of a substance as the amount of energy need to raise the temperature of 1 kg of the substance by 1 K (or $1C^o$). Students should understand that the amount of heat is measured in joules. It is one of the units of energy. Temperature is not a unit of energy. Group experiment. Students have large samples of some substances like wood, some metal like a bolt, or foam. They tie strings on them and put them in very hot water and leave the samples for a few minutes until they are all at the same temperature. They use a cloth or glove to shield their hand. Students touch each sample. They conclude which one has take the most heat from the water. Students describe why heat capacity is the ability of a substance to store heat. It is not conduction, convection, or radiation. Engineering application: The space shuttle gets extremely hot when it re-enters the earth's atmosphere. Temperatures are over 4,000 C higher than the boiling point of iron. Outside the shuttle are special tiles that are extremely good insulators. Why are they needed? Peer Instruction with Concept tests on heat capacity. Students confirm understanding of capacity of a substance to hold heat by considering common substances.

Competences	***Contents***	***Suggested Activities***
		Which substance requires more heat to raise 1 Kg 1 degree centigrade? Here are some specific heats for common substances: • water (4039 J/kg C ^{o}), • air (1012 J/kg C ^{o}) • wood (1700 J/kg C$^{o)}$, , • tin (228 J/kg C ^{o}) • air (1600 J/kg C ^{o}) • brick, (840 J/kgC^o), • wet soil (1200 J/kgC^o) • copper (385 J/kgC^o), and • iron (450 J/kg C ^{o}) Students discuss advantages of building materials in a warm climate. If you were building a house in a warm climate and wanted to keep down the effect of solar heat, what value (high or low) would be good for a roofing material? What substances would make the best materials for a roof? Which would make the worst? Why. How many Joules does it take to raise a Kg of the best material 10 degrees C. How many Joules does it take to raise a Kg of the worst roofing material 10 Degrees C. What material and what color would you paint your roof to make it the worst possible and collect the most heat? Lower specific heats are better because the sun outputs a constant amount of heat. 228 Joules of solar energy would raise a tin roof 1 degree C. That same 228 Joules would raise a brick roof (228/1700) ¼ of a degree. The brick is four times better an insulator. Students brainstorm: What materials could make a roof mostly of air? Design issue: in warm climates high specific heat materials do warm up in the day giving back heat at night. **Group Engineering Project:** Design a house that is energy efficient in the summer. If possible build a model of the house with similar materials. Students should be able to calculate amount of heat using the equation $Q=mc\Delta T$ Where Q = energy in J m = mass in kg ΔT = change in temperature in C^o C =specific heat capacity is J/kg C ^{o}. Students could use the specific heat capacities of different materials to find the amount of heat lost of gained when these materials decrease or increase over a given temperature range.

Assessment

The teacher should assess each student's 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 and concepts like heat, heat transfer, conduction, convection, radiation and specific heat capacity; give examples of good and bad conductors of heat, the three mechanisms of heat transfer from daily life experiences; tell the dimension of the unit of heat and use the relation $C=Q/m\Delta T$ to solve simple problems.

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 the 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: Electricity and magnetism *(21 Periods)*

Unit outcomes: Students will be able to:

- Understand concepts related to electricity and magnetism;
- Develop skill of manipulating problems related to electricity and magnetism;
- Appreciate the interrelatedness of all things;
- Use a wide range of possibilities for developing knowledge of the major concepts within physics

Competences	***Contents***	***Suggested Activities***
Students will be able to: • Demonstrate understanding of electric current using 'the human wire' simulation • Define the term EMF • State the role of EMF	***5. Electricity and magnetism*** **5.1 Modelling electric current, a circuit loop and voltage** *(1 period)* • Modelling motion of charge in a conductor • Modelling the EMF of a battery or power source • Modelling a closed current loop • Modelling group velocity of electrons in a conductor and instantaneous movement the current qualitatively	Classroom Demonstration: The Human Wire The core of electricity is electric current. Students will build an understanding of electric current using a simulation called "The Human Wire". See the document "Modelling with the Human Wire". "The Human Wire" builds a concrete understanding of current before developing deeper ideas. "The Human Wire": The whole class becomes a model for motion of charges in a conductor. One row of students (front to back) becomes one wire. A box at the front of the class models the battery. The box has "battery" painted on it with negative on one end and positive on the other. In the box are about 100 small stones the sizes of cherries. They can be painted with an "e" on them. They represent the electrons. A student stands at the box and pushes all of them to the minus side. That student is the model for the EMF, the electro-motive force. EMF is not a good term. It is not a force or a "push" as measured in Newton. EMF really is a potential to do work by separating charges making them available for travel elsewhere. For a battery the EMF comes from a chemical reaction that separates charges pushing electrons to the negative end. The EMF could be a generator or a photovoltaic. To begin the current a student nearest the "battery" get a stone electron. The EMF person hands out the stone electron, then another then another. The first student passes the stone along. The process continues until the "Human Wire" has brought stone electrons back to the + side of the box where the electron is placed. The EMF quickly pushes the electron from the + side to the – end. The "Human Wire" models motion of electrons, as it occurs in nature. The convention in physics is to consider a current as positive charges. When current was defined centuries ago nothing was known about atoms or electrons. Scientists guessed that + charges moved in a wire; they don't. Students should demonstrate an understanding of current as a flow of negative charges though convention often assumes current flows with + particles from the + side of the battery. Students should appreciate the role of the EMF as the separator of charges and the role as the initiator of charge concentration. When all students in the "wire" have a stone, the instructor stops the model and seeks attention as one electron is "pushed" to the first student. On a table the instructor has 5-8 pucks or books lined up end to end. He puts one book on the end and knocks it as if with a hammer. The last

Competences	Contents	Suggested Activities
• Differentiate between closed and broken circuit	• Modelling thicker wires qualitatively • Modelling a broken circuit • Modelling a parallel circuit qualitatively **5.2 Modelling qualitatively an electric light bulb** *(2 periods)* • Inquiry into what students think light bulbs look like. • Preliminary drawings of a light bulb circuit. • Investigate what real light bulbs look like. • Compare filaments in light bulbs	puck or book moves. The electrons in a conductor move the same way. Students model this motion, moving in unison, putting forward the electrons. The last electron is put back in the battery at the same instant the first one is put in the wire. Students dialog about how this current is instantaneous, but also has a finite speed for any one electron. The speed the electrons is called the Drift Velocity. It is much slower than the instantaneous reaction of a current. What happens with thicker wires? Students model a thicker wire in the "Human Wire" by adding more rows of students. Students practice current flow with three rows outwards and three rows returning. More students passing and collecting stones may be needed. They practice motion in unison modelling returning to the + end at the same time that new electrons are pushed out. Students explain why there always must be the same number of electrons going out as going in. Students explain why thicker wires carry more current than thin ones. What happens with a broken wire? The instructor moves to the back of the room with a scissors and models cutting the wire. The connection between some students is broken. Students describe why the current must stop and not have electrons build up at the broken piece. What happens if the wire is split into two paths and reunited later. Students model a four row out and four row return circuit. While doing this modelling the teacher "splits" the returning human wire at one point with a card board, saying "Let's make this section two different wires" He makes a drawing on the board of circuit with a "T" junction that splits current, and later re-unites it. Students discuss the flow rate of electrons in the two paths, and later after they re-unite. Students quantize the current by describing how, if the original current was 4 electrons per second in the larger wire, the new split wire must have 2 electrons per second each. Demonstration: The instructor calls up four students and gives each one a battery, some wires, and a 6v bulb. The students are asked, before they try it out, what types of connections will make the bulb light. Each student commits to the blackboard a drawing of what connections he or she thinks will make the bulb light. They try to light the bulb with that connection. The class discusses the different connections with similarities and differences. The instructor does not praise or criticize any drawing or note that any is right or wrong. Group activity: Groups of students receive one or more light bulbs. These can be 6v bulbs, 220 V bulbs, bulbs from automobiles or other sources (avoid headlights – too much glass). It does not matter that the bulb is non-functional. With a covering of cloth to prevent flying glass, the instructor helps the students break the class covering. Only the instructor should break the bulbs and collect the glass. He should be sure that all glass is removed from student stations. Care should be taken not to break any more the delicate filament. Students observe and compare the filaments. They make drawings of at least two filaments and bulb structures in their notebooks. Students compare the thickness of the posts with that of the filament. Is the

Competences	***Contents***	***Suggested Activities***
		filament half as thin, more than that, than the posts. Filaments are made from tungsten, the metal with the highest melting point.
	• Explore the structure of a real light bulb identifying filaments, tip, screw base and support posts.	In their notebooks students make careful drawings of the structure of the light bulbs without glass. Students identify the tip, the screw base, the posts and the filament. Using a pliers or wire snips students break apart the screw base to follow the connections from the posts. Students recognize that one post goes to the point, another goes to the screw base. Students identify the function of these connections in a drawing.
	• Identify complete and incomplete circuits	Using the drawings on the board made by the first students, the class identifies connections that work and some that don't. Groups of students vocally describe why some drawings won't light the bulb. Students identify incomplete circuits. They also identify compete circuits. Students describe exactly why the design of a bulb makes a complete circuit.
• show with the help of a diagram a filament and bulb structure	• Model current flow in a circuit with a bulb qualitatively	Students build a 3-row out, 3-row return with a student "bulb" on the return wire. The filament in the "bulb" must be thinner than the wire – it should be several students in just one row. Students predict what happens to the current in this single row. Students predict what will happen to the real filament with a real current.
	• Modelling a fuse	• The teacher builds a model of a circuit with a 12v bulb from an automobile and a 12 v car battery. The circuit includes a switch and a place where a bare wire piece con be inserted. The bare wire piece should be very visible. The instructor inserts several different wires, starting with one the thickness of other wires in the circuit. He then inserts thinner and thinner, using the switch each time. He asks students to predict what will happen and why? He highlights different ideas and their reasons without making critical commentary. At one point the wire glows and emits sparks and melts. Students explain why this is happening. The instructor asks, "What use is a broken circuit?" He highlights responses and mentions a fuse, if students do not come up with it.
• describe the role of a fuse	• Building a parallel circuit	Students use wires, a battery and two bulbs to build a parallel circuit. They remove one light and observe the results. From their knowledge of current flow, they explain why there is any difference in brightness.
• define the terms: electric current and voltage • define the term Ampere	**5.3 Relationship of Volts, Current and Resistance** *(2 periods)* • Definition of Amp	Current is physically number of charges passing a point per second. Charge is measured in Coulombs. One ampere of current represents one coulomb of electrical charge (6.24×10^{18} charge carriers) moving past a specific point in one second. The unit of measurement of current is not practical in common usage. 10^{18} is a bit large. One does not need to know the electron count. The Ampere is considered, in practice, a fundamental unit of current with no reference to the number of charges.
• define the term resistance • state Ohm's law • show the electrical symbol of a resistor	• Definition of Volt	Voltage is a measure of the ability to do work. It is a scalar quantity. It can be thought of as "potential push" or "pressure" in an electric circuit. It is not a force. The voltage is supplied by some source of Electro Motive Force like a battery or a generator or a photovoltaic cell.

Competences	***Contents***	***Suggested Activities***
• use Ohm's law in the solution of simple circuit problems	• Definition of Ohm and Resistance • Ohm's law • Validity of Ohm's law	Resistance of an object, qualitatively, is the electrical opposition to the passage of current. It is measured in Ohms, symbolised by the Greek letter Ω omega. The quantities V, I and R are related by an equation called Ohm's Law. $$V = IR$$ The equation appears as a simple proportion. Ohm's law is commonly presented as the defining equation for either I or R. Unfortunately this is not quite true. Ohm's law is a relationship that is valid only under certain circumstance and certain temperatures and with some substances. It is not a true physical law like Newton's Laws or the Law of Gravitation, or the Conservation of Energy which are valid from atomic scale to the size of galaxies and at all times or temperatures. There are many non-Ohmic substances that are of great importance. Diodes and transistors are but two. Students should understand that Ohm's law is a relationship that is valid for many but not all cases.
• read measurements in ammeters and voltmeters • draw circuit diagrams using symbols of an ammeter and voltmeter • connect ammeters and voltmeters correctly in simple electric circuit	**5.4 Measuring electric current, resistance and voltage** *(2 periods)* • Measuring electric current with an Ammeter • Measuring voltage with a volt meter	Students will employ an ammeter to measure the current in a parallel circuit with two lights and a 6v batter. They will demonstrate that an ammeter, because it measures flow, must be inserted into the circuit. Students, with their qualitatively knowledge of circuits will predict the value of the current in Amperes in the wire from the battery and in each of the parallel branches. Students will measure that those two currents and describe any pattern they see. Students will attempt, if possible to put in two different bulbs that make one brighter and one dimmer. They will predict which side has the larger current or if the current is the same. They will measure, then explain any patterns they see. Which part of the parallel circuit has more current? Why? Students will explain why the sum of the currents is the same as the current from the battery. A voltmeter measures electrical pressure. It is a difference between two points. Students will measure the voltage over the battery, then over the two lights separately. Students will explain why the voltage values have the same quantity. Students will measure voltage over other parts of the circuit. Sometimes the reading is zero, sometimes it is not. Students will explain why there are zero and non-zero readings. Students will remove one bulb from the circuit but first make a prediction about the current. Use identical bulbs. Will it be the same or different from the parallel circuit? They will explain their results.
• measure the resistance with a voltmeter and an ammeter		Students will measure the voltage over the bulb and the current of a single bulb circuit. From Ohm's law, they will make a measurement of the resistance of bulb. If a brighter bulb is available, students will make a measurement of its resistance. They will explain what the effect of a higher or lower resistance is on the brightness of the bulb.
• read colour codes of resistors		Students will repeat the above circuit measurements with a pair of resistors of known value. They will measure current and voltage and calculate resistance with Ohm's law. They will compare their calculated value with the marked value on the resistor. Resistance commonly has an error of plus or minus 10%.

Competences	***Contents***	***Suggested Activities***
	• Measuring resistance with a voltmeter and an ammeter.	Students should measure the resistance of an unknown resistor (a resistor with tape on it) and confirm their measurement. The instructor will help them read the colour coding through a chart at the front of the class. Students should practice using Ohm's law to solve problems with simple electric circuits. Where possible they should confirm their calculations by setting up circuits and making appropriate measurements.
• list the factors that affect resistance of a conductor		Students should appreciate the factors that affect the resistance of a metal conductor. • Length – as the length increases the resistance increases. • Cross sectional area – as the cross-sectional area increases the resistance decreases. • Material of the conductor – the resistance depends on the material from which the conductor is made. • Temperature – as the temperature increases the resistance increases. The resistance of a particular metal conductor is constant provided its temperature remains constant. Students could carry out experiments to investigate these factors.
	• Factors affecting resistance	Students could measure a variable resistor (a potentiometer). • The readings of current and voltage are taken and the resistance calculated. • The variable resistor is used to produce several different values of current and corresponding values of voltage and the resistance is calculated each time. Students will brainstorm about the possible uses of a potentiometer. (volume control)
• identify series and parallel connections of resistors • calculate the equivalent resistance of resistors connected in series • calculate the equivalent resistance of resistors connected in parallel	**5.5 Formulas to calculate series and parallel or combinations of resistors** *(3 periods)* • series combinations of resistors	Students should understand that two or more resistors may be connected in series and in parallel and that this affects the total resistance of the circuit. Students should appreciate that any series combination of resistors simply increases the resistance of the circuit. They should provide a justification for this effect SERIES RESISTANCE: Rtotal=$R_1+R_2+R_3+\ldots$ ...... Where …. Means continue as long as there are more values. Parallel resistances present a different problem. They do not add directly. They add by reciprocals.
• tell the advantages of series and parallel combinations of resistors	• parallel combination of resistors	$\frac{1}{R_{total}}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}+\ldots$ Students could connect resistors in different ways in circuits and measure the currents and voltages in the circuits. The circuits should be pure series or pure parallel. From this they may confirm the relationship between total resistance and resistors placed in series, and in parallel. In circuits where:

Competences	***Contents***	***Suggested Activities***
		• R_T = total resistance • R_1 and R_2 etc are the resistance of individual resistors. The total resistance of resistors in series will have the same current will flow through each resistor connected in series. Voltages will be different over each resistor. The voltage across each resistor connected in parallel will be the same. The current through each will be different from the total current from the battery. PEER INSTRUCTION on pure series and pure parallel circuits. Circuits may contain mixtures of series and parallel patterns. It is possible to replace a parallel pattern by an equivalent resistance calculated from the above formulas. It is possible to replace a series pattern by the total equivalent resistance from the above formulas. Students should use the formulae to calculate the total resistance of different networks of resistors.
	• Calculating resistance of series and parallel combination of resistors by replacement of equivalent values.	Students could use an ohm meter to measure the resistance of different combinations of resistors. They could use this to confirm the results of calculations. Students should understand that power is defined us the rate of converting energy. Electric power is defined as P=IV. It can be derived from more basic equations. From Ohm's law Power can also be express in many ways. $Power = IV = I^2R = \frac{V^2}{R}$ From P=IV students should be able derive all the above variations.
• Define the term electric power • Use the relations $P=VI=I^2R=V^2/R$ in the solution of simple circuit problems	• Energy and power in an electric circuit	Students should calculate the power dissipation of a two resistor series circuit. They should calculate the power dissipation of a two resistor parallel circuit. They should explain why the two are the same or different. Confirming understanding of circuits with "CIRCUIT JEOPARDY" The board has many diagrams of simple circuits with integer values for resistance and voltage or current. A? is over the variable they must calculate. Some just have pictures like "what is a Series circuit" or for another picture " what is a mixed series and parallel circuit" or a voltmeter is over a wire. "What is a voltage of zero?" is the answer. The entries in the board should be made from student writing from the labs. Ask them to draw the circuit or make the problem.
• Describe in words or by sketch the general shape and patterns of magnetic field lines around a straight current carrying wire	**5.6 Electromagnetism** *(3 periods)* • Magnetic effect of a current • Magnetic field due to a straight current carrying wire	Students should appreciate that a wire carrying a current has a magnetic field around it. Students should be able to sketch the pattern of the field lines. Student should be able to apply the Screw Rule to predict the direction of the field lines. Students could observe the shape of the magnetic field by using a metal wire pushed through a hole in a piece of card. The wire is connected to a cell and a switch. Iron filings are sprinkled onto the card. When the switch is switched on, and the card is gently tapped, the iron filings will line up to show the shape of the magnetic field. A plotting compass can be used to show

Competences	***Contents***	***Suggested Activities***
• Tell that current carrying wires act as a magnet • Use the screw rule to determine the direction of the magnetic field lines around a straight current carrying wire • Define the term solenoid • Sketch the pattern of magnetic field lines around a solenoid • Compare the magnetic field lines around a bar magnet and a solenoid	• Magnetic field around a solenoid	the direction of the field lines. Students could be asked to predict what happens if the direction of the current is reversed. Students could use the same method to observe the shape of the magnetic field around a loop. The wire is bent to form a complete loop which passes through the card. Students should appreciate that a solenoid is a long coil made of many turns. Students could use the card method to observe the shape of the magnetic field around a solenoid. The wire is pushed up and down through the coil a number of times to form the solenoid. Students should be able to sketch the pattern of field lines around a solenoid. Students should compare the magnetic field pattern around the solenoid with that produced by a bar magnet to observe that they are similar. Students could use iron filings and a plotting compasses to map and draw the magnetic lines of force around a bar magnet. Students should activate the solenoid and conjecture about uses for such a moving object. Where are solenoids used in practical life? (locks, cars) Students should understand that an electromagnet consists of a coil wound on a soft iron core. When current flows in the coil the core is magnetized. Unlike a permanent magnet the magnetism of an electromagnet is temporary. Student should be able to apply the Right-Hand Grip Rule to predict the magnetic polarity of the solenoid.
• Use the right hand rule to specify the polarity of an electromagnet	• Electromagnet	Students could make a simple electromagnet by winding plastic coated copper wire around an iron nail. The turns must be close together and always wound in the same direction. The electromagnet should be supported in a wooden stand. The free ends of the wire should be connected to form a circuit with an ammeter, a variable resistor and a battery. When switched on the electromagnet can be used to attract paperclips. Students could use this arrangement to investigate the factors that affect the strength of the electromagnet by varying the current and the number of turns of wire and noting the number of paperclips the electromagnet will support.
• Tell what makes an electromagnet strong	**5.7 Electric motor** *(2 periods)*	Students should understand that strength of the electromagnet increase as • the current increases • the number of turns on the coil increases.
• Predict the direction of the resulting force on a current carrying wire in a magnetic field		Students should understand that a current carrying conductor placed in a magnetic field will experience a force due to the field. This is called the motor effect. Students should observe the effect of the magnetic field on a wire that is very thin. They will use very thin foil taken from a gum wrapper and put current though it. Put a resistor in the circuit to limit current. Use two batteries to supply the current. Students should observe the effect of changing the direction of the current. Students should conclude that magnetic fields

Competences	***Contents***	***Suggested Activities***
• Explain the turning effect produced in a motor • Label the parts of a motor and show its symbol.	• Right-hand grip rule	around a current cause a force. Students should see what happens if one battery is disconnected. Students should conclude that magnetic fields only operate on moving charges. It does not matter what the material of the wire is. The material could be non-magnetic but it is pulled or pushed if there is a current. Fleming discovered that magnets act on moving charges. He discovered that the Right-Hand- Rule describes the force. Put your pointer finger in the direction of the current (defined as positive charges though really it is electrons). Very thin wires can be substituted for the foil from gum wrappers. Students should understand how to use Fleming's Right-Hand Rule to predict the direction of the force. Students could use Fleming's Right Hand Rule to predict the direction of the force, then see what happens when the direction of the current is reversed and when the poles of the magnet are reversed. Students will build a simple DC motor – the Paper Clip motor. See the document "Paper Clip Motor" http://motors.ceressoft.org/ They need some thin coated wire a battery and two paper clips and a magnet. Students follow the directions to make the paper clip motor. They predict the direction of rotation with Flemings rule. They verify the prediction. They experiment with different magnets and different numbers of coils to make an optimal motor.
• Identify electrical appliances that contain motors		Students could identify electrical appliances that contain electric motors. Students could build their own simple motors from a motor kit. Peer Instruction on motors
• Define the terms: induced current, and voltage • Tell the factors that affect the size and direction of induced voltage	**5.8 Electromagnetic induction** *(2 periods)*	Students should understand that if a conductor cuts the lines of a magnetic field a voltage is induced across the ends of the conductor. If the conductor is part of a complete circuit an induced current can flow in the circuit. This effect is called electromagnetic induction. Students could investigate electromagnetic induction using • a length of wire connected to a sensitive, centre-zero ammeter and placed between the poles of a U-shaped magnet, the wire is moved in and out of the magnetic field • a coil of many turns connected to a sensitive, centre-zero ammeter, a bar magnet is moved in and out of the coil. Students could investigate the effect on the voltage of moving the wire/magnet at different speeds and in different directions and using a stronger magnet. Students should understand that current is only induced when the conductor is cutting field lines, not when it moves along them or is stationary. Reversing the direction of movement reverses the direction of the current. The same effect occurs if the conductor remains still and the magnetic field is moved past it.

Competences	***Contents***	***Suggested Activities***
• Describe the generation of electricity by the rotation of a magnet within a coil and of a coil of wire within a magnetic field		The size of the current is increased by increasing • the speed of movement • the strength of the magnetic field • the number of turns on the coil
• Explain the working principle of a bicycle dynamo	• Bicycle dynamo	Students should understand that a bicycle dynamo uses electromagnetic induction. As the bicycle wheel turns a magnet rotates near a coil of wire so the magnetic field lines are cut by the wire and a voltage is induced across the ends of the coil. Students could look at a real bicycle dynamo to see how it works.
• Label the parts of an a.c generator and its symbol	**5.9 Generator** *(1 period)*	Students should be able to label the parts of a simple a.c. generator consisting of a coil rotating within the poles of a fixed C-shaped magnet. As the coil rotates magnetic field lines are cut and a voltage is induced. The coil is attached to slip-rings, which rotate with the coil, and press against carbon brushes.
• Distinguish between a.c and d.c current	• a.c. and d.c. current	Students should understand that the simple generator produces alternating (a.c.) current, meaning that the direction of the current changes every half cycle. Students could draw a graph to show the output of a simple generator over one complete cycle and match it with diagrams to show the positions of the coil during the cycle. Students should appreciate that direct (d.c.) current flows in one direction only.
• Tell what a transformer is • Give lists of an electrical appliances in home that have transformers	**5.10 Transformers** *(2 periods)* • Step-up • Step-down	Students should appreciate that a transformer is used to increase or decrease the value of an a.c. voltage. Students should be able to list some common electrical appliances in the home, such as mobile phone chargers, that use transformers. The metal of the transformer traps the magnetic field of an ac current and forces almost all of it through the secondary winding. Students should investigate the field using a compass.
• Identify transformers as a step up and step down • Use the formula power in primary=power in secondary to solve problems related to transformers		Students should investigate applying a DC current to a transformer such as a flyback transformer from a non-functional TV. Flyback transformers have a very high number of secondary windings. They are step up transformers. The instructor should connect a 6v battery to the primary coil and connect the secondary coil to a light bulb. Release the primary coil and observe what happens. Students should explain why there is a small flash. They might try touching the secondary coil when the primary is released. A very short duration high voltage current is generated from the decaying energy of the magnetic field.
• Apply $V_p/V_s = N_p/N_s$ to solve related problems to transformer		Students should understand that the transformers in the home change a higher a.c. voltage to a lower a.c. voltage. These are called step down transformers. Step up transformers can be used to change a lower a.c. voltage to a higher one. Students should appreciate that transformers are very efficient machines. If a transformer was 100% efficient then: power supplied to primary coil = power supplied to secondary coil

Competences	***Contents***	***Suggested Activities***
		Power, P = I x V Where • I = current in A • V = voltage in V. So for the transformer: $$V_p \times I_p = V_s \times I_s$$ Students should practice using the equation to solve simple problems.
• Give reasons why high voltages are used to transmit electricity • Tell what transformers are used for in power transmission • Label the parts of a transformer and show its electrical symbols	**5.1.1 Power transmission and conversion of energy** *(1 period)* • Power plants in Ethiopia • Electric safety rules	Students should understand that transformers are used in a National system to transmit electricity. • When electricity is transmitted some power is lost as heat in the cables. • The power loss is minimized if the current is reduced. • P = I x V therefore in order to reduce the current the voltage must be increased. • This is done using a step-up transformer. • High voltages are unsafe for consumers. • The voltage is reduced using a step down transformer before the electricity reaches the consumer Students should understand that a transformer consists of two coils of insulated wire, the primary and secondary coils, wound on a soft iron core. When an alternating voltage is applied to the primary coil it induces an alternating magnetic field in the iron core. The alternating magnetic field passes through the secondary coil and induces a alternating voltage across its ends. If the secondary coil is part of a complete circuit an alternating current is produced in it. Students should be able to label the parts of a transformer. Students could be shown a demonstration of a transformer with a.c. voltmeters connected across the ends of the coils. Students could investigate the structure of a transformer that no longer works by pulling it apart.

Assessment

The teacher should assess each student's 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 terms and concepts like electric current, resistance, potential difference, solenoid, electromagnet, induced current ,magnetic fields , transformer, step up transformer, step down transformer voltmeter, graphs; give lists of electrical appliance, factors affecting the strength of electromagnet, size and the direction of induced current; tell the relation between current, voltage and resistance, step down and step up transformers, magnetic fields exert force, working principles of generators, the difference between motor and generator, ac and dc currents, the use of transformer electric safety rules; use formulae for series and parallel resistors, ohms law, input out put voltages and currents, to solve simple problems.

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 the 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: Light *(12 Periods)*

Unit outcomes: Students will be able to:

- Understand concepts related to light ;
- Develop skill of manipulating problems related to light ;
- Appreciate the interrelatedness of all things;
- Use a wide range of possibilities for developing knowledge of the major concepts within physics

Competences	***Contents***	***Suggested Activities***
Students will be able to: • Tell that light is propagated in a straight line	***6. Light*** **6.1 What is light?** *(1 period)* • Kinds of light	Students volunteer what they think light is: what forms it comes in, the different kinds of light. The instructor puts them in lists to see patterns of a scientific view of light or a non-scientific view (example light in a person's eyes)
• Give examples of translucent, transparent and opaque materials	• Usage of "light" that is not scientific but valid in another study	The instructor asks "What is not light?" Again he puts the suggestions in lists the suggestions by pattern. If some entries are not there, such as x-rays, radio waves, Infra Red, ultra violet, the instructor adds them. Students appreciate that there are kinds of light that people cannot see. Students appreciate that there are common usages of "light" that are not scientific, such as light from a person's spirit. This does not mean they are not valid, just that they are not measurably scientific.
	6.2 How does light travel? *(1period)* • Straight line motion • Pinhole camera	Students should understand that light travels in straight lines. Students could carry out a simple experiment to verify this using 3 holes in cards. The holes should be relatively small like ½ of a paper punch. The holes must be placed so they are not in the same relative position. A group of students holds the cards so that some object like a flag or some object The cards are placed several centimetres apart. The object can only be seen when the holes line up not the bottom of the cards. . If one of the cards is moved, so the holes are no longer in a straight line the light can no longer be seen.
	• Kinds of transmission	Students use simple pinhole camera to observe an image of the outside. They analyze the image. It is inverted. They explain what must happen to have light from the tallest object end up on the bottom of the image. They should make a diagram of the outside and the pinhole camera and light coming from the top and bottom objects in the object they are looking at. They must use a ruler. Why is the image smaller than the object? Students should explore to see if they can change the size or make it right side up.
	• Absorption	Students should understand that light passes through some materials and is partially or completely absorbed by others. They should be able to give examples of translucent, transparent and opaque materials. Students could use a torch and samples of different materials to determine which are translucent, transparent and opaque.

Competences	***Contents***	***Suggested Activities***
• Define the term reflection • Identify reflection as regular and diffuse	**6.3 Reflection of light** *(2 periods)* • Reflecting surfaces	Students should understand that some surfaces do not allow light to pass through them but reflect it. When light reflects from an uneven surface, such a sheet of paper, it reflects at lots of different angles. This gives a diffuse reflection. When light reflects from an even surface, such as a mirror it all reflects at the same angle. This gives a regular reflection.
• Define the terms: angle of incidence, angle of reflection and normal line		Students should understand what is meant by the terms angle of incidence, angle of reflection and normal. Students could use a bulb with a slit, to form a narrow ray of light, and a mirror to investigate the laws of reflection.
• State the laws of reflection	• Laws of reflection	Students should be able to state that: • the angle of incidence is equal to the angle of reflection • the incident ray, the reflected ray and the normal all lie in the same plane.
• Construct a ray diagram to illustrate the formation of a virtual image in a plane mirror • State the properties of an image in a plane mirror	• Image formation by a plane mirror	Students could investigate the formation of an image in a plane mirror using optical pins. They should identify the position of the image on the other side of the mirror. Students should be able to construct a ray diagram to illustrate the formation of a virtual image in a plane mirror. Students should be able to state that the image in a plane mirror is • the same size as the object • upright • the same distance behind the mirror as the object is in front • virtual • laterally inverted
• Distinguish between real and virtual images		The idea of real and virtual images should be discussed with the students.
• Draw a diagram to show how two mirrors can be used to make a periscope	- Periscope	Students could build a periscope using a cardboard. Slits are cut to the sides of the tube to hold 2 mirrors at 45^{o}. These can be taped in place. Students should be able to draw a diagram to show how two mirrors can be used to make a periscope
• Define the terms: focal point, vertex(pole),principal axis, focal length, radius of curvature of curved mirrors • Construct a ray diagram to illustrate the formation of an image in curved mirrors		Students could be given a concave mirror, a convex mirror and bulb with a set of slits, to form parallel rays of light. They should observe that the parallel rays converge when they are reflected from the concave mirror and diverge when they are reflected from the convex mirror. Students should be introduced to the terms focal point, vertex (pole), principal axis, focal length and radius of curvature for curved mirrors. Students should be shown how to produce construction rays to locate the position of an image. • A ray through the centre of curvature is reflected back along its own path. • A ray parallel to the principal axis is reflected through the focal point. • A ray through the focal point is reflected parallel to the principal axis.

Competences	***Contents***	***Suggested Activities***
• State the properties of an image formed in a concave and convex mirrors	**6.4 Image formation by curved mirrors** *(3 periods)* • Concave mirror • Convex mirror	Students should practice using these rays to locate the images of objects at different positions relative to concave and convex mirrors. For concave mirrors students should be able to state that • for an object placed beyond the focal point of the mirror a real, inverted image is formed. The position and size of the image depends on the distance from the object to the mirror. • For an object placed between the focal point and the mirror an virtual, upright image is formed that is larger than the object. For convex mirrors students should be able to state that the image produced is always virtual, upright and smaller than the object.
• Define the term refraction as the bending of light when passing from one medium to another. • Explain what happens when light crosses a boundary	**6.5 Refraction of light** *(2 periods)* • Metaphor for refraction	Students should understand that refraction is the change in direction of light as it moves from one medium to another. It takes place because the speed of the light changes as it crosses the boundary between the media. Students develop a metaphor for understanding this change of speed. Imagine the light is an axel with two wheels that rotate independently. The axel is travelling on a fast pavement but is angled so that it will go into some grass or perhaps sand. The grass or sand slows that wheel down. The axel must turn toward the perpendicular. One wheel hits before the other.
• State Fermat's least time principle	• Fermat's least time principle	Fermat, a French scientist, proposed a powerful idea. Light travels from one point to another in the shortest possible time. Students should be able to state the principle and apply it. A good metaphor uses a lifeguard on a beach that must save someone who is in the water at a distance to the right side as one is facing the guard. He travels fastest on land and slower on the water. Students should make the drawing and put in several paths of the lifeguard to that swimmer. They should analyze which one they think is the fastest. Too much on land makes the trip slow. Too much in the water makes it very slow. The guard must spend most of the time on the land with less in the water. Think about the conditions if the guard with a dolphin who is slow on land but speedy in the water. What path would the dolphin take? Light moves slower in water, much like the lifeguard. Students could investigate refraction by shining a ray of light through a glass block and drawing the path of the incident ray as it enters the block and the path of the refracted ray as it leaves the block. The block is removed and normal to the edge of the glass should be added. The students trace clearly the incident path and the refracted path. The angle of incidence should be varied to observe the effect this has on the angle of refraction. The student should apply the metaphor of either the axel or the swimmer to explain why the ray was bent. Students should appreciate that lenses are devices that make use of the refraction. They should be shown convex and concave lens so that they can distinguish between them.

Competences	***Contents***	***Suggested Activities***
• Distinguish between convex and concave lenses • Define the terms: optical centre, focal point, principal axis, focal length, radius of curvature of a lens • Construct a ray diagram to illustrate the formation of an image in a convex and concave lens • Describe the nature of the image formed by convex and concave lenses	**6.6 Lenses** *(3 periods)* - Convex - Concave • Image formation by a convex lens • Image formation by a concave lens	Students could be given a convex lens, a concave lens and a bulb with a set of slits, to form parallel rays of light. They should observe that the parallel rays converge after refraction by the convex lens and diverge after refraction by the concave lens. The students should be introduced to the terms focal point, principal axis, optical center, focal length and radius of curvature for a lens. Because light can pass through the lens in either direction there is a principal focus on either side of the lens. Students should appreciate that rays of light from a point on a very distant object are approximately parallel. They could carry out a simple experiment to find the approximate focal length of a lens. Use a sheet of white paper as a screen. Hold a convex lens so that rays of light from a distant object, such as a house or a tree, form a clear image on the screen. The screen must be at the principal focus of the lens. Measuring the distance form the lens to the screen gives the (approximate) focal length of the lens. This could be done with a ‘fat’ lens and a ‘thin’ lens. Students should be shown how to produce construction rays to locate the position of an image. • A ray through the optical centre is undeviated. • A ray parallel to the principal axis will pass through the focal point after refraction through the lens • A ray through the focal point will emerge parallel to the principal axis after refraction through the lens. Students should practice using these rays to locate the images of objects at different positions relative to concave and convex lens. For a convex lens students should be able to state that • if the object is further away from the lens than the principal focus, a real, inverted image is formed. The size of the image depends on the position of the object. The nearer the object is to the lens, the larger the image. • for an object placed between the focal point and the lens a virtual, upright image is formed behind the object. The image is magnified – the lens acts as a magnifying glass. Students should attempt to project an image from a concave lens. It will not project an image because the rays diverge. Students should experiment with a torch with a paper slit over the opening to make a vertical beam of light. Concave lenses make the rays spread out. Students should understand that a mirage is an effect produced by refraction. It occurs because the light is progressively refracted as it passes through increasingly warm layers of air. Students could describe and discuss mirages they have seen. Students should understand that dispersion is the spreading of white light into its component colours by refraction. If white light is shone onto a prism the different colours of light are refracted by different amounts. The red is refracted least and the blue is refracted most. The

Competences	***Contents***	***Suggested Activities***
• Describe the causes of a mirage	• Mirage	geometry of the prism is such that this refraction happens in the same sense as the light enters and leaves the prism. Prisms are an older way to see spectra. A modern way uses grooves on a film. The grooves on a broken CD make an excellent spectroscope.
• Define the term dispersion • Demonstrate dispersion of light using a broken CD	• Dispersion of light	Students could produce dispersion by shining a narrow ray of light onto a prism and onto a sheet of white paper. They should observe the order of the colours in the resulting spectrum. This is not a very effective demonstration. Group lab activity. Students build their own spectroscope using pieces of a broken CD, an empty cereal box and some tape. Instructions are found at http://www.cs.cmu.edu/~zhuxj/astro/html/spectrometer.html
	• Viewing spectra with a diffraction grating CD	Groups of 4-5 make a spectroscope. The cereal box just needs a cut at about 60 degrees and an entrance for the light to bounce off the grooves on the CD. Fragments of CD's work fine. The students make a very thin horizontal slit to view the spectrum.
	• Viewing solar spectra at noon and at dusk • Viewing spectra of fluorescent lights or sodium vapor lights to see emission lines.	Students use this powerful spectroscope to view: • solar spectra • spectra of torches with or without filters • spectra of incandescent lights and observe relative strengths of colors • spectra of fluorescent lights to find emission lines of mercury • spectra of neon lights to see spectra lines of neon • spectra of sodium vapor lights to see the spectra of sodium in them. Students should compare the different kinds of spectra: solar, and emission spectra of the various elements. In later courses they will make measurements of the wavelengths of these lines.

Assessment

The teacher should assess each student's 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 terms and concepts like, translucent, transparent and opaque materials, reflection of light, angle of incidence, angle of reflection, normal line, vertex, focal point, principal axis, focal length, radius of curvature, optical center for both curved mirrors and lenses, mirage and dispersion; tell light propagate in straight line, the properties of imagers formed by plane and curved mirrors, lenses, the difference between real and virtual images, the difference between regular and diffuse reflections, difference between concave and concave mirrors, difference between concave and convex lenses; construct ray diagrams that illustrate image formations in plane mirror, concave mirror, convex mirror, concave lens, convex lens;

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 the 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.